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The first ten years' existence of the Czechoslovakian Railways, (1)

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Figs. 1 to 31, pp. 330 to 365.

A. — Organisation.

Under the Peace Treaties, the Czechoslovakian Republic acquired part of the railways formerly belonging to Austria and Hungary, as well as a few kilometres of lines previously belonging to Prussia. In addition, there were a certain number of railways belonging to private companies.

Seeing that the Headquarters services, as well as most of the divisional services, remained outside the Republic's frontiers, it was first of all necessary to build up the administrative side of the railways.

At the present time, the supreme administration of the Czechoslovakian railways is in the hands of the Ministry of Railways. The Ministry has two functions : the control of all railways in Czechoslovakia in general, and the general management of the State Railways.

At the head of the Ministry is the Minister of Railways, a Member of the Government of the Czechoslavakian Republic.

Questions of capital importance, especially when of large financial consequence, are reserved to the Management Committee, the decisions of which have to be ratified by the Minister. The Management Committee was formed in accordance with the law 404/1922, and the government order 206/1924 dealing with the administration of State undertakings not principally exercising administrative functions. This Committee consists of the heads of the different sections of the Ministry of Railways, together with the two senior area managers of the State Railways as well as a representative of the Ministry of Finance.

The Ministry of Railways is organised into seven sections, each consisting of several departments. The working of the State Railways is directed by Area Managements which, as a general rule, are divided into eight departments (staff, legal, permanent way, rolling stock and locomotive running, operating, commercial, audit and accounts). Attached to the Praha-Jih and Brno Area Managements, there are in addition other departments representing the headquarters services (pensions, wagon control, rates, central designing office for the workshops, inspection of material).

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(1) Translated from the French.

The service of the State Railways is controlled from the financial point of view by a Commission of Control attached to the Ministry of Railways, and in the last resort by the Supreme Court of Finances.

The diagram below gives a synoptic table of this organisation (table A).

B. — **Extent and development of the railway system.**

1. — *Kilometric length of the lines.*

Czechoslovakia with its railway system (see map fig. 1) of a length of 13 407 km. (8 381 miles) occupies, as regards the length of all the railways, the ninth place amongst the European States. The Czechoslovakian State Railways operating a railway system of a length of 13 154 km. (8 173 miles) also hold amongst European railways the fifth place as regards the kilometric length of the lines, only being surpassed by Russia, Germany, Poland and Italy.

The growth of the Czechoslovakian railway system during the last ten years, that is to say, from 1918 to 1928, is shewn in table I.

2. — *Lack of railway facilities having regard to the needs of the new State.*

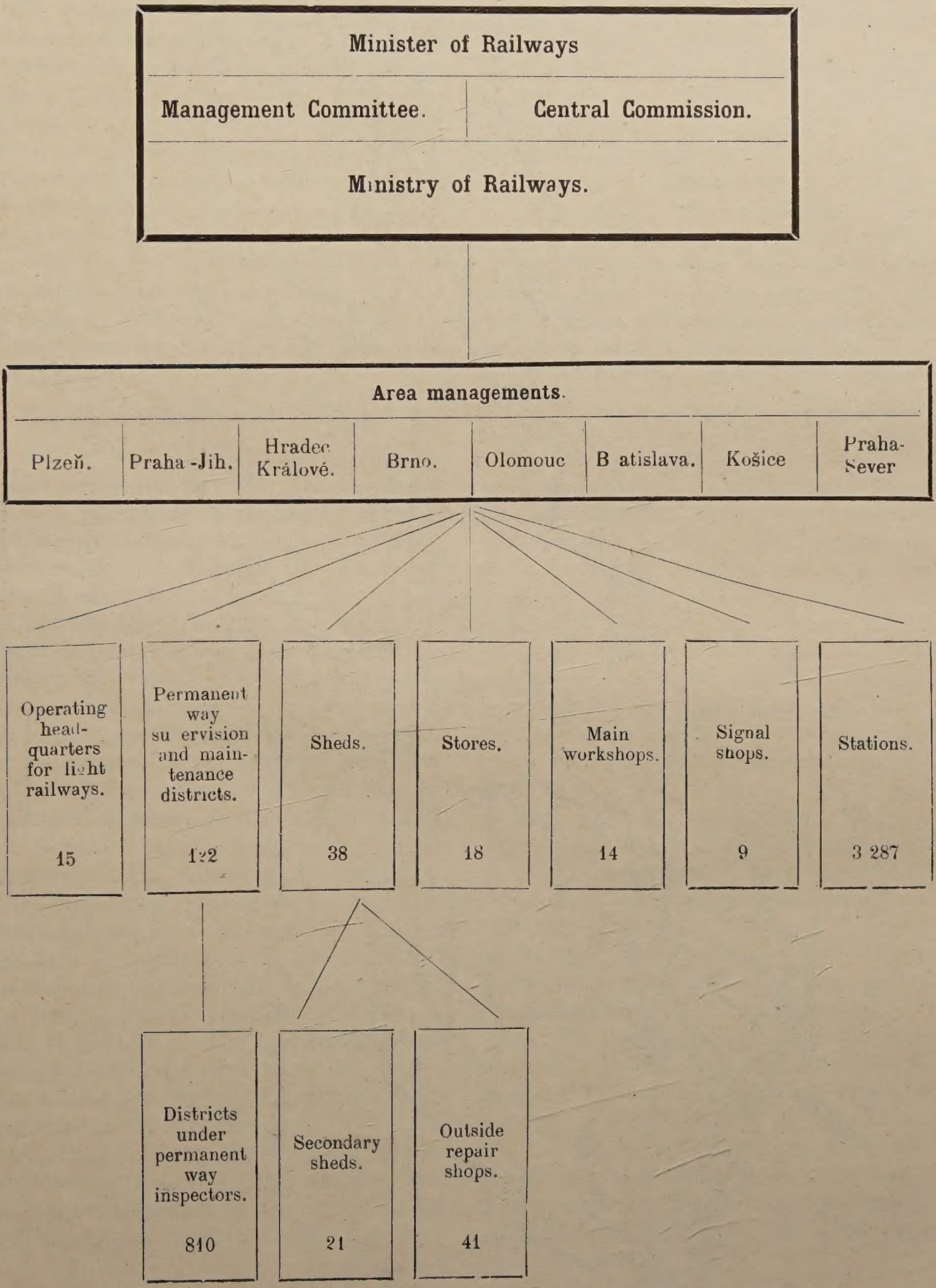
The railway system remaining after the war on the Czechoslovakian territories had been much neglected as regards maintenance during the war. Even in the case of the management of the main lines, the system did not meet the needs of the new State. In both old Austria and Hungary, the railway lines converged as a fan on the capitals, Vienna and Budapest. For these reasons, the principal lines on the territory of the Czechoslovakian Republic generally ran North and South, whereas communications from East to West were very poor, this part of the system being almost entirely composed of lines of secondary importance. In particular, the railway service between the different countries of the ancient Czech Kingdom, Bohemia, Moravia and Silesia, on the one hand, and Slovakia and Sub-Carpathian Russia on the other, were entirely inadequate. The one and only main line connecting the Czech countries with Slovakia, that is to say, the Přerov-Bohumín-Košice line ends by a considerable detour at the frontier of the State and was for some time the subject of litigation between Czechoslovakia and Poland. The line running from Brno, the capital of Moravia, as far as Slovakia through the Vlára pass was a secondary line of light construction, and the conditions were unfavourable as regards the direction of traffic and the gradients; it had no adequate extension to the East on Slovakian territory. The third railway service in the South with Slovakia was formed by two insignificant light railways, Břeclav-Kúty and Kúty-Bratislava, of purely local importance.

This state of affairs was due to some extent to the technical difficulties found in the territory considered. It were, however, especially the predominant pre-war political influences that had formed the greatest obstacle to the construction of railways connecting two branches of the same nation which, from the point of view of their economic life, were complementary to one another.

Another weakness of the Czechoslovakian railway system, immediately after

TABLE A.

Organisation of the Czechoslovakian State Railways.



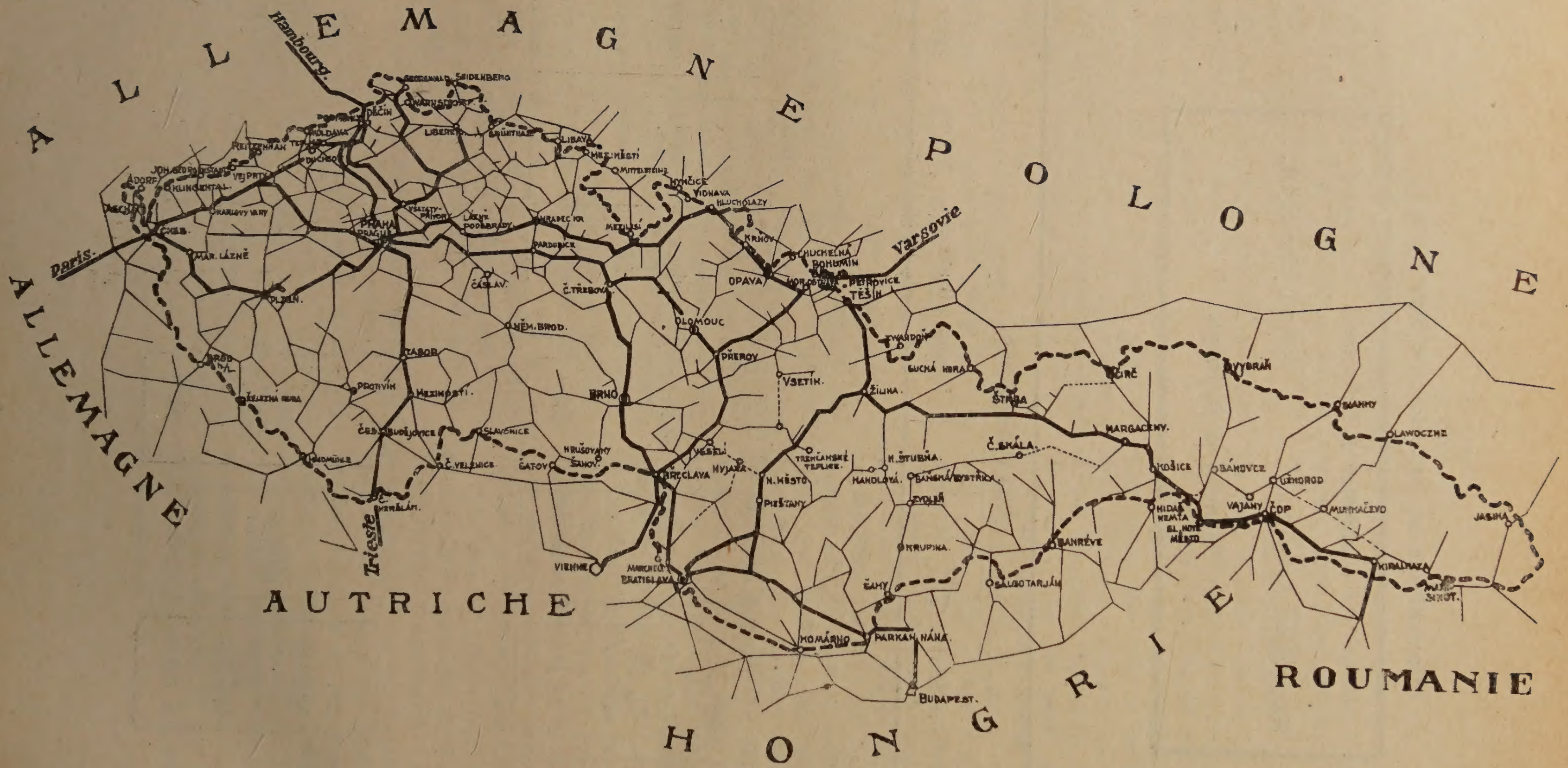


Fig. 1. — Czechoslovakian Railway System.

LEGEND :

━━━ Main lines.

┄┄┄ Lines under construction or projected.

the war, was found in the fact that the new frontiers, especially that between Czechoslovakia and Hungary, crossed at several points and in a very inconvenient manner the existing railway lines. For example, three lines to the North of Banréve were completely separated by the new frontiers from the remainder of the Czechoslovakian system: one railway junction was across Hungarian territory.

The new frontier stations between Czechoslovakia on the one hand, Austria, Hungary, Rumania and Poland on the other, were not equipped for frontier requirements.

3. — *New railway construction.*

This is the reason why one of the principal cares of the new Administration was to make good these needs. First of all it was necessary to perfect the railway communication between the Czech and the Slovak countries.

Immediately after the Revolution, the light railway between Břeclava and Bratislava was rebuilt as double track main line — 68 km. (42 miles) was opened progressively as completed, being opened as a whole to public service in 1921.

In this way a first class direct line was obtained between Bratislava, the capital of Slovakia, and the Danube port of the Republic. The whole of the stations of this line were remade: the buildings were rebuilt to a large extent and the bridges strengthened. It was necessary on this line to rebuild thirty large bridges in steel of a total weight of 30 000 quintals (1 476 tons). The bridges were built up of temporary steel members carried on wood piers, and were gradually made permanent during the years 1922 and 1923, that is to say, the wood piers were replaced by masonry piers and the temporary bridge members completed (fig. 2).

The separate lines to the North of Banréve were connected with the remainder of the system by a new line laid through Tchecoslovakian territory.

In order to obtain more direct communication with Užhorod, the capital of Subcarpathian Russia, during the years 1920-1921, the Banovce nad Ondavou-Vajany railway in Eastern Slovakia (20 km. = 12.4 miles) was constructed. The bridges on these lines, originally provisional structures, were completed as permanent works during the years 1923 and 1924. These bridges have a total weight of 85 000 quintals (4 183 tons): the flood bridge at kilometre 17 5/6 has a length of 200 m. (656 feet); the bridge across the Laborec river is 100 m. (328 ft.) long.

In 1920 the Government sanctioned the programme for the construction of new railways intended to improve communication with Slovakia. The programme provided for the construction of a total length of 558 km. (347 miles) the cost of which was provided for in the act to the extent of 964 million crowns. At present prices, these costs would be increased by about one and a half thousand million crowns. With a view to carrying out the programme, in 1921, a Central Construction Office was organised which has formed part of the Railway Ministry since 1923. Up to the present only part of the programme has been completed. Of the new railways built in accordance with this programme, 104 km. (65 miles) have so far been handed over to the Operating Department. The carrying out of this programme is still in progress.

In 1923, in accordance with the programme, the construction of the *Zvolen-Krupina* line was taken in hand to give a railway service between the important city of Zvolen in Central Slovakia and the country situated to the south thereof. It is a single track main line of a length of 32.8 km. (20.4 miles); its worst gra-

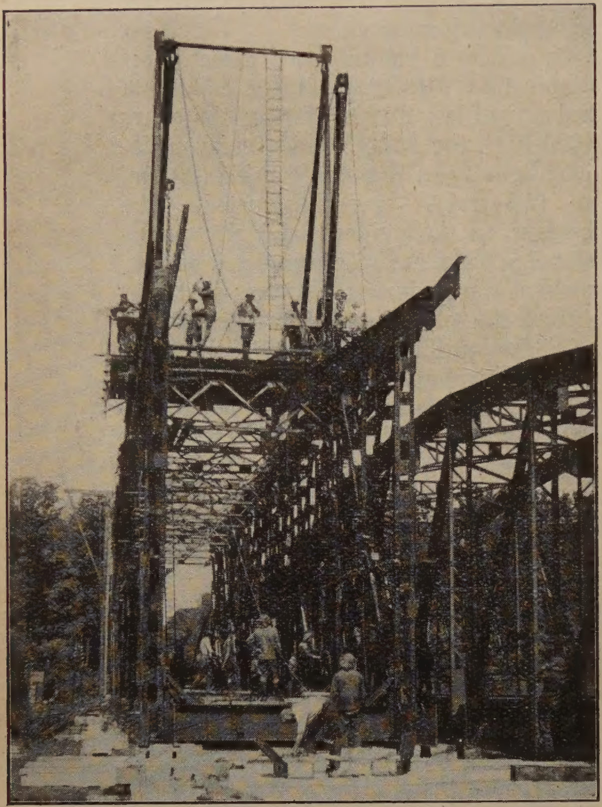


Fig. 2. — Construction of a temporary bridge on the Roth Wagner system near Lanžhot on the Morava, on the Břeclav-Kúty line.

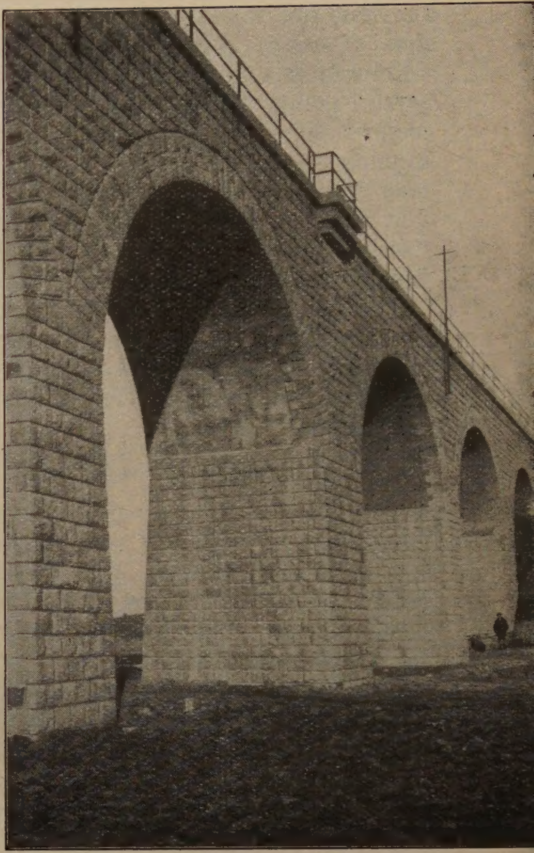


Fig. 3. — Viaduct at kilomètre 15 8/9 on the Zvolen-Krupina line.

dient is 1.4 per cent, and the shortest curve is 300 m. (15 chains) radius. Rails weighing 35.6 kgr. per metre (71.76 lb. per yard) are used. The highest point of the line is 427 m. (1 401 feet) above sea level. The line was completed in January 1925 (fig. 3).

The construction of the *Vsetín-Bylnice* line was begun in 1923 : this line in Eastern Moravia gives access to a very unusual and picturesque part of Moravia along the Slovakian frontier, and known as Valašsko. This is a single track line 39.1 km. (24.1 miles) long. The steepest gradient is 1.2 per cent : the smallest curve has a radius of 400 m. (20 chains) and in exceptional cases 300 m. (15 chains). The highest point is 472 km. (1 549 feet) above sea level. The stations temporarily have a length of siding to hold 120 wagons; provision has been made to extend them to hold 150 wagons. This line serves territory of great natural beauty, which offered many difficulties

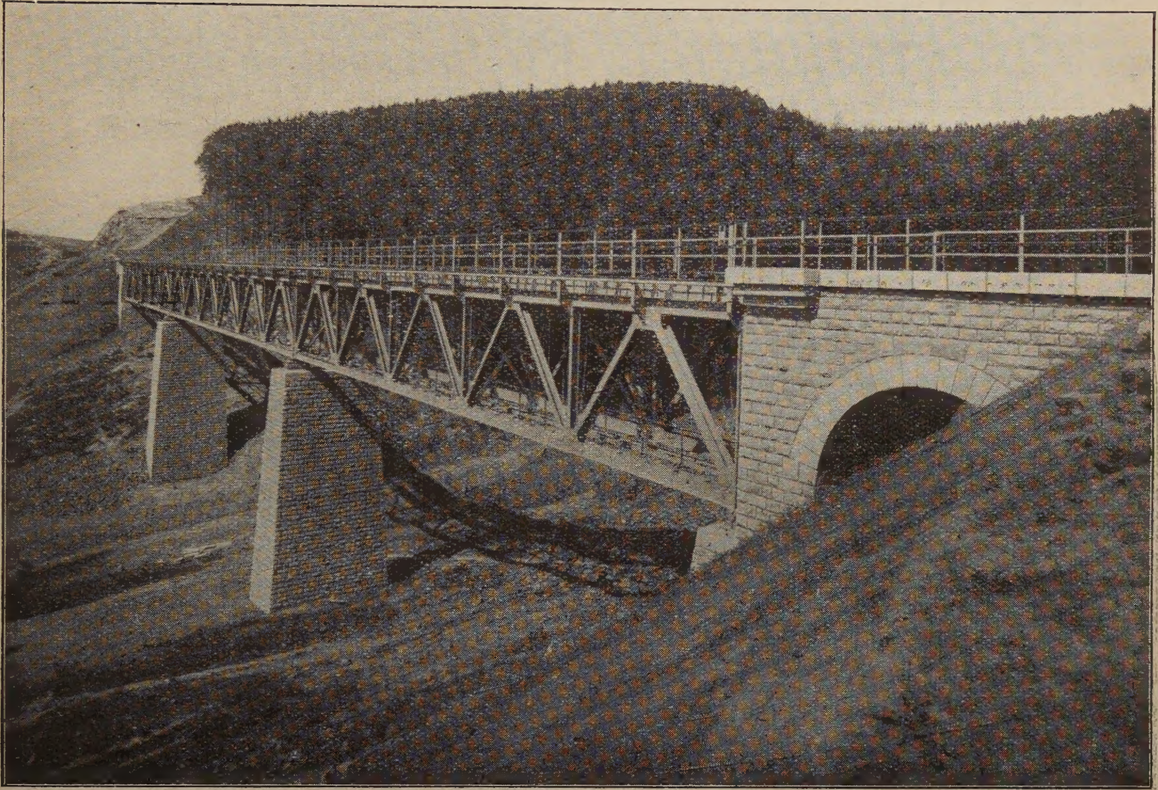


Fig. 4. — Viaduct at kilometre 27 3/5 on the Vsetín-Bylnice-Brumov line.

as regards construction, so that a number of costly structures has been necessary : amongst others, there is a tunnel near Navojna 888 m. (971 yards) long. This line was opened in October 1928 (figs. 4, 5, 6).

In 1923, on the same legal basis, the construction was started of a transversal railway passing through the centre of Slovakia from West to East. The new railway between Brno-Moravia and Košice-Slovakia, of a length of 608 km. (378 miles) was built up by including already existing lines to a length of 426 km. (265 miles), such as the :

1. Veseli nad Moravou-Mové město nad Vahom line, 67.5 km. (42 miles);
2. Handlová-Horni Štubna line, 18.16 km. (11 miles);
3. Červená-Skála-Margecany line, 95 km. (59 miles).

Of the first line we have just mentioned with a length of 67.5 km. (42 miles), the construction of which was taken in hand on the 6 July 1923, the section *Veseli nad Moravou-Slovenská Myjava*, 32 km. (20 miles) long was opened to public service in 1927. This line includes three tunnels, two small, one of a length of 486 km. (532 yards) the other

247 m. (270 yards), and a long tunnel under the Polana forming a passage through the White Carpathians and having a length of 2 420 m. (2 647 yards): this line also has many viaducts. Amongst these we will mention the Lipov viaduct crossing the valley of the Velička river of a length of 209 m. (887 feet) and a height of 23 m. (75 1/2 feet) above water level, of girder construction with the track carried on top of the girders, in 5 spans (figs. 7, 8, 9, 10).

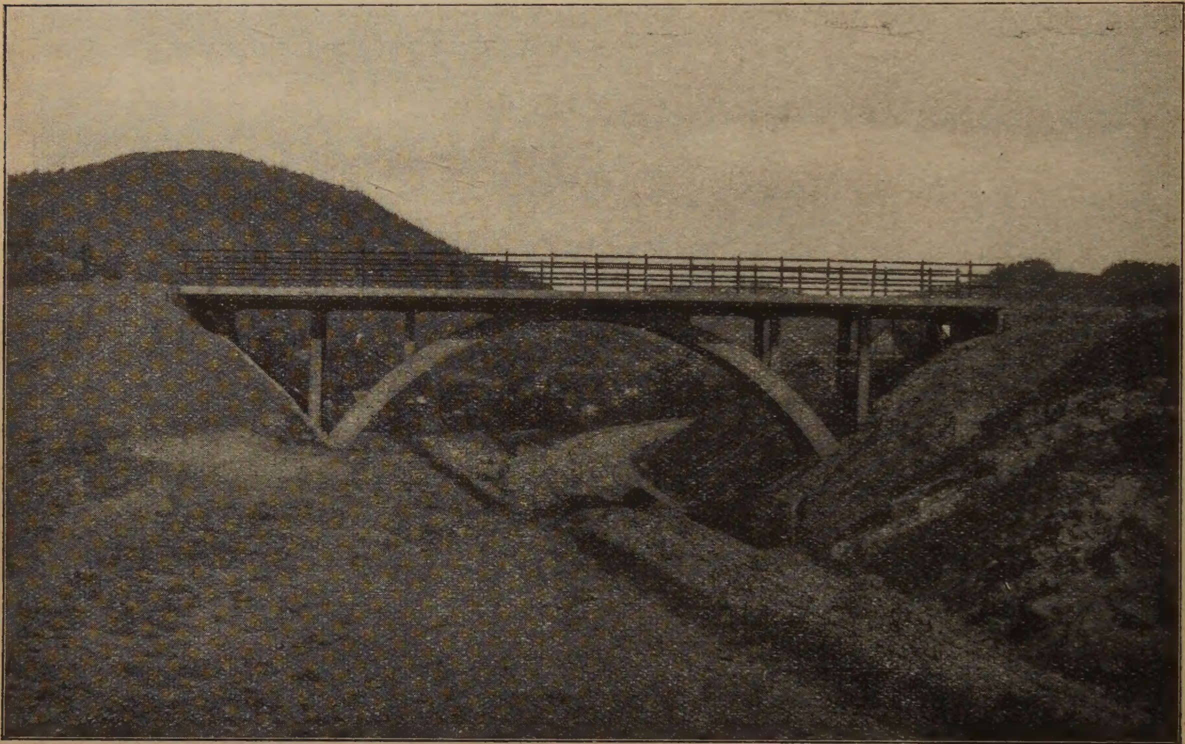


Fig. 5. — Reinforced concrete road bridge on the Vsetín-Bylnice line, (kilometre 17 4/5).

An important link of the new line in central Slovakia is formed by the *Handlová-Horni Stubna* short junction line which presents the characteristics of a mountain line with many constructional difficulties. Horni-Stubna station is situated 620 m. (2 034 feet) above sea level. Handlová station near which are coal mines, the only ones in central Slovakia, is situated at a height of 427 m. (1 401 feet) above sea level.

The construction of this link was started in the autumn of 1927. This link includes, in addition to a series of works of lesser importance, four great viaducts and five tunnels, the longest of which passes under Mount Bral, and has a length of 3 004 m. (3 285 yards). This will be the longest tunnel in Czechoslovakia. Deep cuts alternate here with high embankments. There were more than 860 000 m^3 (1 124 898 cubic yards) of excavation, and a total volume of masonry of nearly 150 000 m^3 (196 203 cubic yards). The steepest gradient is 1.6 per cent. The construction of this line ought to be completed in 1931.

The scheme of the last part of the new transversal line of the Slovakia line *Červená Skála Margecany* of a length of 95 km. (59 miles) is already completed and the construction will be taken in hand shortly.

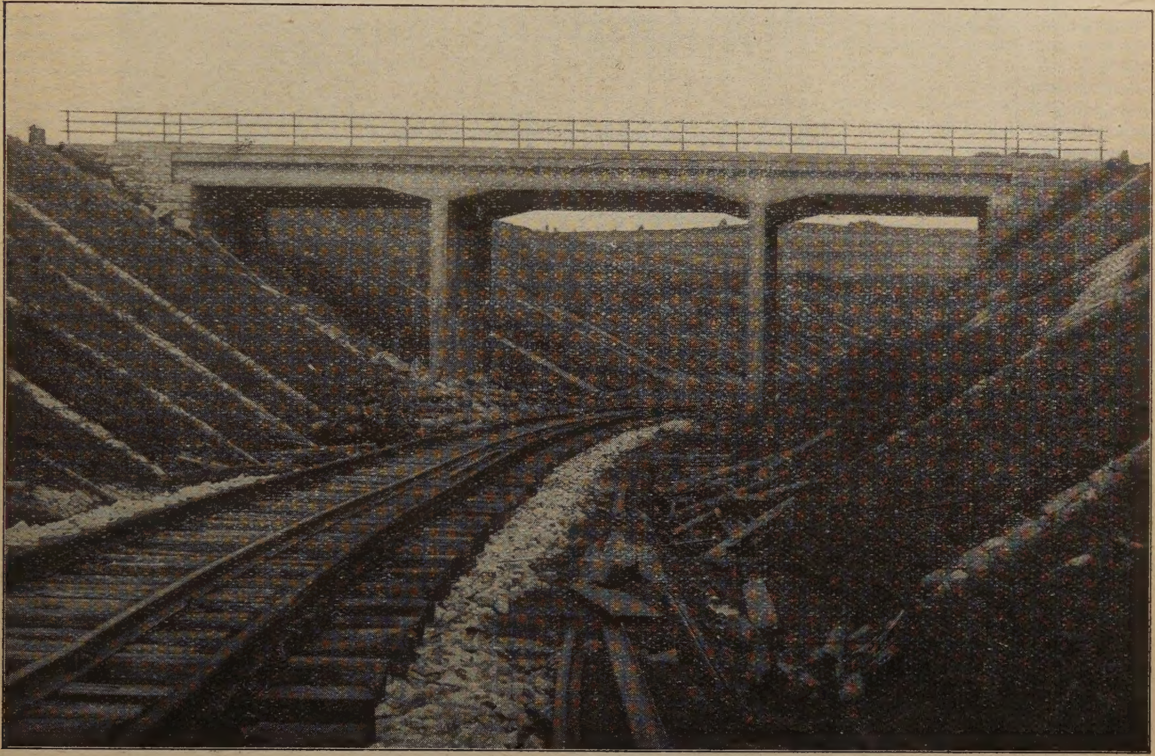


Fig. 6. — Reinforced concrete road bridge on the Vsetín-Bylnice-Brumov line, (kilometre 36 7/8).

The construction of new railways has cost up to date 435 million crowns, 228 of which for the lines in Slovakia. When the construction programme mentioned has been completed, the economic situation of the central Slovakia districts will be sensibly improved, and these regions, until now difficult of access, will be brought into closer relations with the rest of the territory of the Republic.

4. — *Improvement and equipment of lines already in operation.*

Whilst completing the system by building new lines, special attention has also

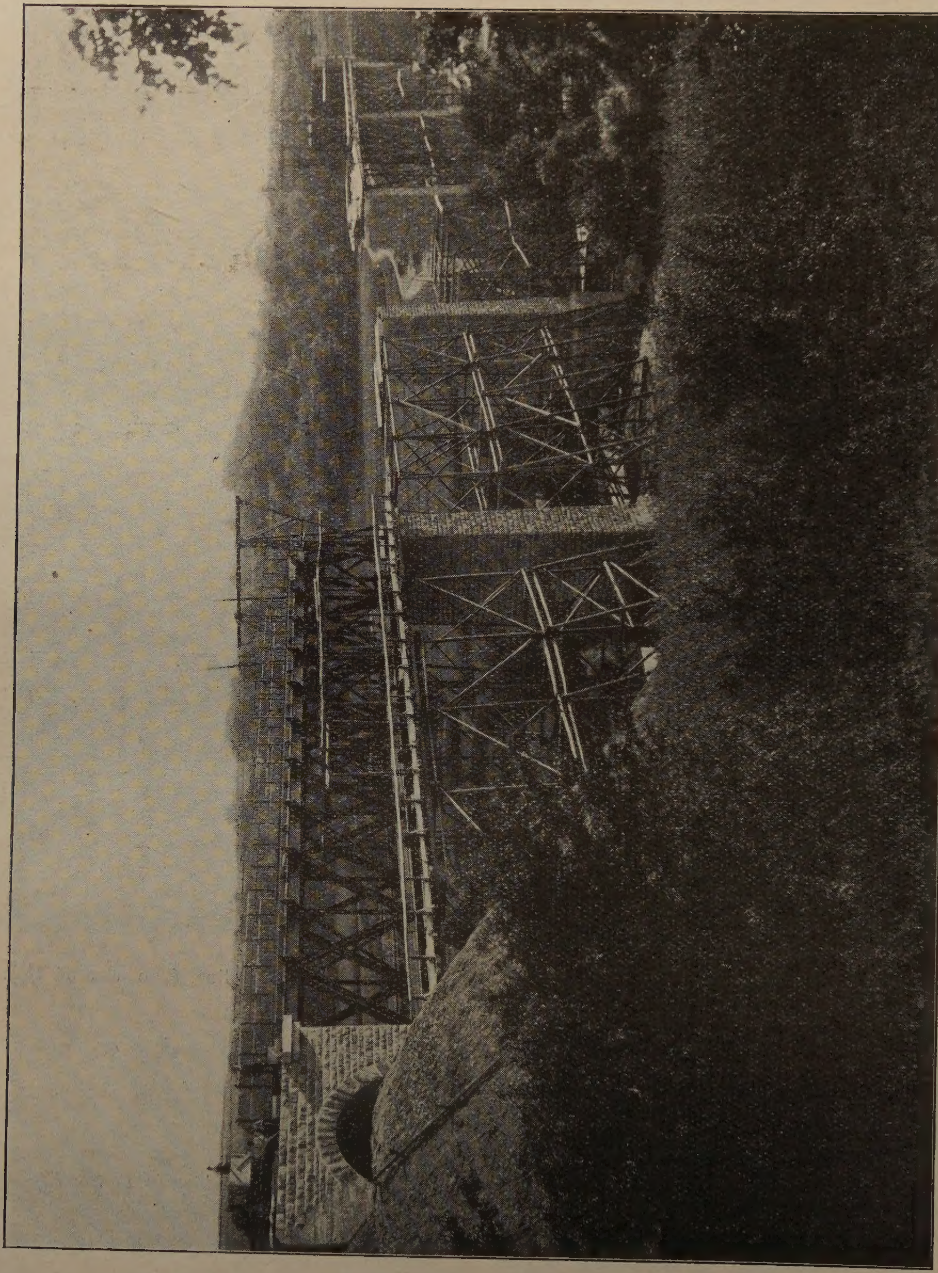


Fig. 7. — Viaduct on the Veselí-Nové Město line (kilometre 42 6/9), under construction.

been given to the remaking of the lines already operated by the State. Some of these lines have lost their pre-war importance : for example, the former Emperor Francis-Joseph main line running from Prague to Vienna, and in particular the section Mezimosti-České Velenice, has fallen to the status of a secondary line, as has the old North West railway line in the Časlav-Šatov Section, etc. On the other hand, other lines have acquired greater importance. The line running across the Republic from West to East — the Cheb-Plzeň-Praha-Česká-Třebova-Olomouc-Přerov-Bohumín-Košice-Čop-Jasina, from which branched off at Ceská Trebova the no less important branch Česká-Třebova-Brno-Břeclav-Bratislava-Szob — has become the main line of communication of the Czechoslovakian Republic. As an important cross line has remained the line of the old Ferdinand-Railway : Břeclav-Přerov, joining at Přerov to the West-East system mentioned above.

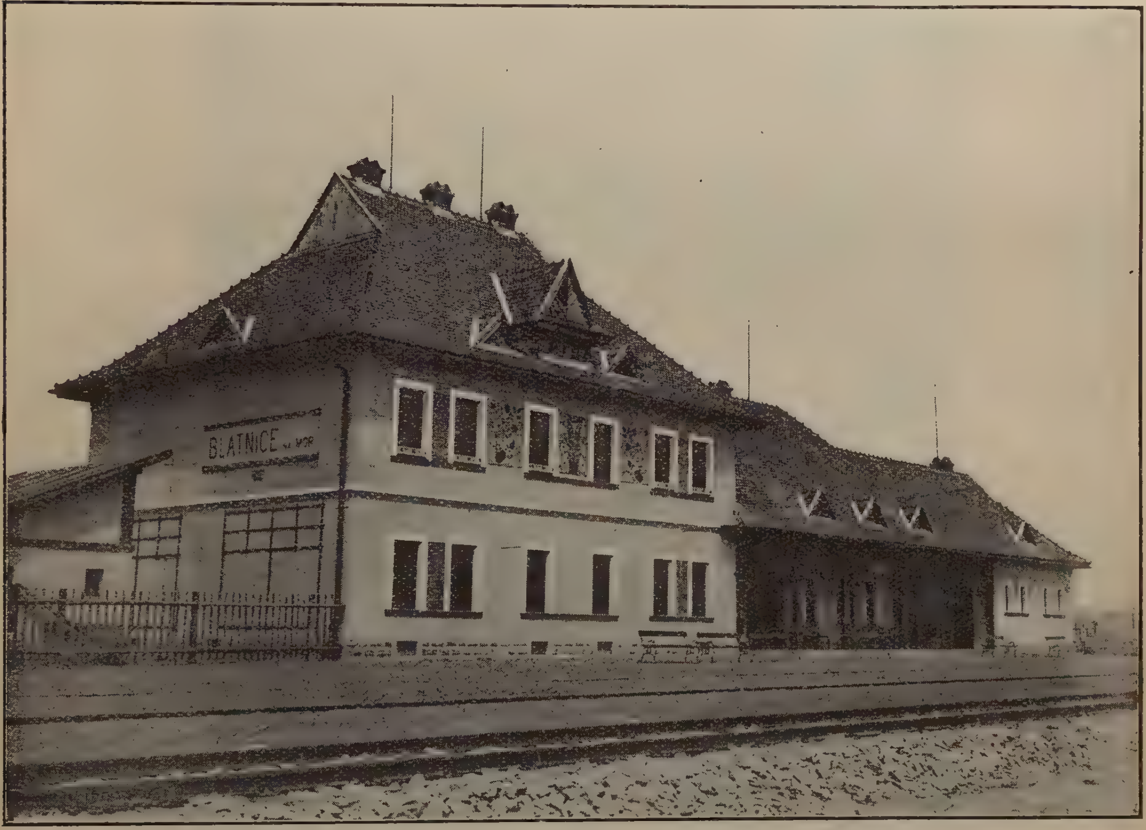


Fig. 8. — Station building at Blatnice on the Veselí-Nové Město line.

The lines connecting Praha with the

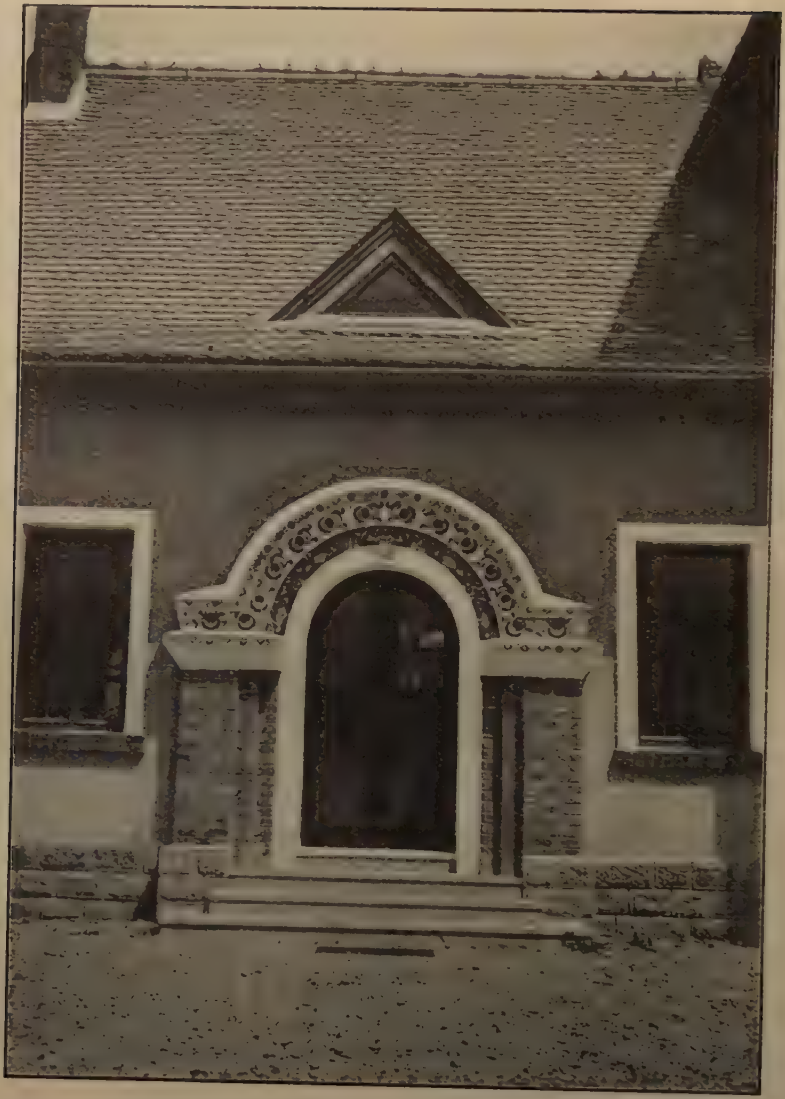


Fig. 9. — Detail of the station building at Lipov on the Veselí-Nové Město line.

industrial districts of the North and East of Bohemia, as with neighbouring Germany, are also of considerable importance.

At the same time, it was necessary to adapt to the new traffic conditions the Czechoslovakian system which had been much neglected during the war, an adaptation which took place after the most urgent upkeep and repair work had been carried out.

This work was done both by doubling important lines until then single, and by the systematic strengthening of the formation of the track and of the bridges; by enlarging the stations, as well as by providing marshalling yards at appropriate centres. In this way, as an example, a second track has been, or is being, laid on the sections : Plzen-Zdice (62 km. = 38.5 miles), Česká-Třebova-Olomouc-Přerov (110 km. = 68.3 miles), Vážec-Batizovce (18 km. = 11.2 miles,) on the West and East arterial line of the Republic. The same thing is being done on the Litorémice-Střekov (25 km. = 15.5 miles) and Kralupy-Lovosice (59 km. = 36.7 miles) running from Prague towards the North and on the important junction line Prague-Lisá (29 km. = 18.0

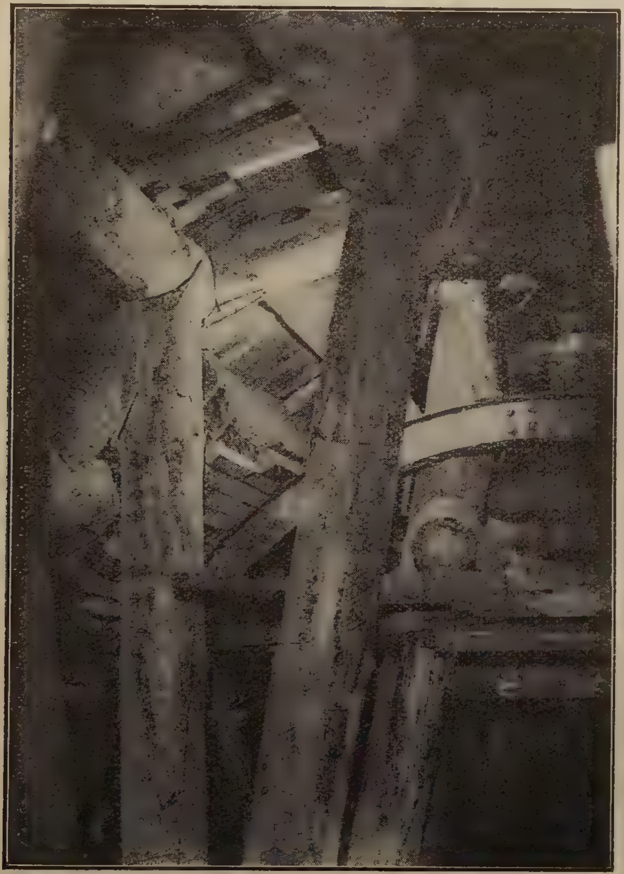


Fig. 10. — Tunnel under the Polana, dètail of shuttering.

miles) connecting Prague with the double track line of the former North-West railway and giving communication between Prague and the very important commercial district of Eastern Bohemia : finally, in the Brno-Břeclava (61 km. = 39.9 miles) section on the already mentioned branch from Česká-Třebova to Brno-Bratislava and Szob.

In all, as much as 200 km. (124 miles) of second track has been laid on the main lines.

It must be realised that the lines of the former Austrian State Railways were of light construction in comparison with that of other European Railways. The axle load allowed on the main lines could not exceed in 1918, 14.5 t. (14.3 English tons). This low axle load hindered the building of locomotives of sufficient power to meet the traffic needs on many lines in Czechoslovakia. The Administration as a result drew up a definite programme for the strengthening of the majority of the lines in question. The whole of the railways operated by the State were divided into four classes :

Class I covers normal gauge lines with gradients not exceeding 1.6 per cent and with speeds of over 80 km. (50 miles) an hour or having a very heavy goods traffic, amounting to 5 000 000 gross tons annually per kilometre (8 000 000 English tons per mile) of track and also of the lines with slower and lighter trains, but on which it will be necessary to admit the passage of vehicles with an axle load exceeding 16 t. (15.7 English tons).

On those lines will be laid a steel superstructure system A, that is to say, having 44.35 kgr.-rails (89.30 lb. per yard) with either 21 or 20, or even 19-21 sleepers per 15 m. (49-foot) rail, according to the running speed allowed.

On these lines, vehicles with an axle load up to 20 t. (19.7 English tons) will be allowed to run; for speeds below 60 km. (37 miles) an hour up to 22 t. (21.7 English tons). Those locomotives with perfectly balanced rotating and reciprocating parts can have an axle load of up to 20 t.; otherwise 18 (17.7 English tons).

Class II includes the other standard gauge main lines and, in addition, the secondary lines.

In this class are included all lines of speeds of 45 to 80 km. (28 to 50 miles) an hour, with a traffic of less than 5 000 000 gross tons per kilometre (8 000 000 English tons per mile) of line, lines over which it will not be necessary to allow vehicles having an axle load above 16 t. (15.7 English tons) to pass.

On these lines will be laid a permanent way system X having rails of 35.65 kgr. (71.86 lb. per yard) with 19 up to 23 sleepers per 15 m. (49-foot) rail according to the train speed allowed.

On these lines are allowed to run vehicles with an axle load of up to 16 t. (15.7 English tons), and locomotives with the same load, when perfectly balanced; otherwise, locomotives with a 15-ton axle load.

Class III includes the other standard gauge lines, and especially the light railways with speeds below 45 km. (28 miles) an hour. On these lines will be laid new permanent way with rails exceeding 30 kgr. (60.47 lb. per yard). Vehicles having an axle load up to 16 tons (15.7 English tons), as well as locomotives with an axle load up to 14.5 t. (14.3 English tons) can be allowed on these lines.

Class IV takes the narrow gauge lines. These latter are laid with 26 kgr. (52.41 lb. per yard) rails for the metre (3 ft. 3 3/8 in.) gauge, and 22 kgr. (44.35 lb.

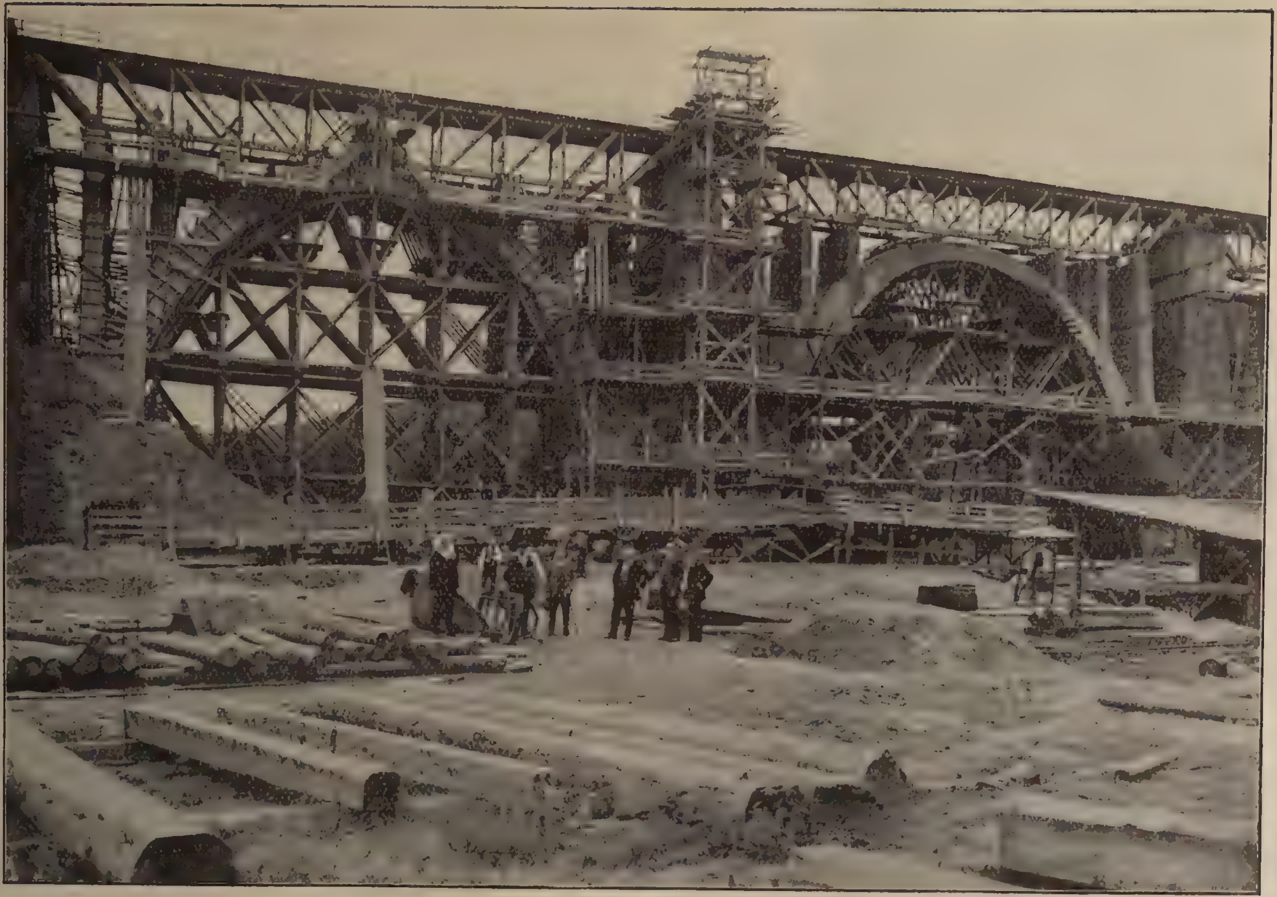


Fig. 11. — Viaduct on the Praha-Turnov line, kilometre 65 5/7, under construction.

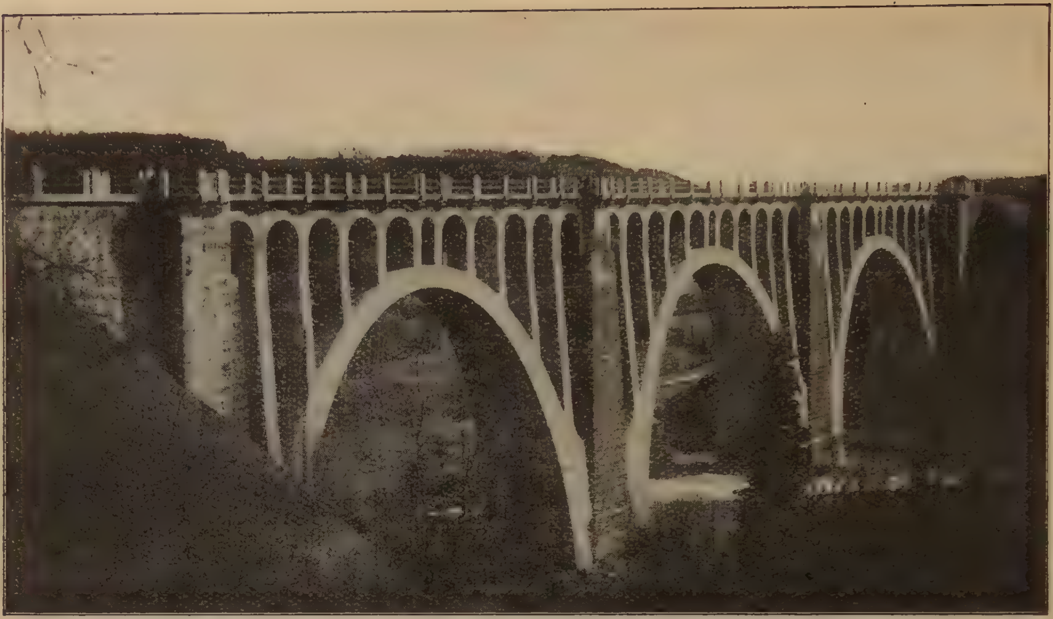


Fig. 12. — Viaduct on the Praha-Turnov line, kilometre 65 5/7, completed,

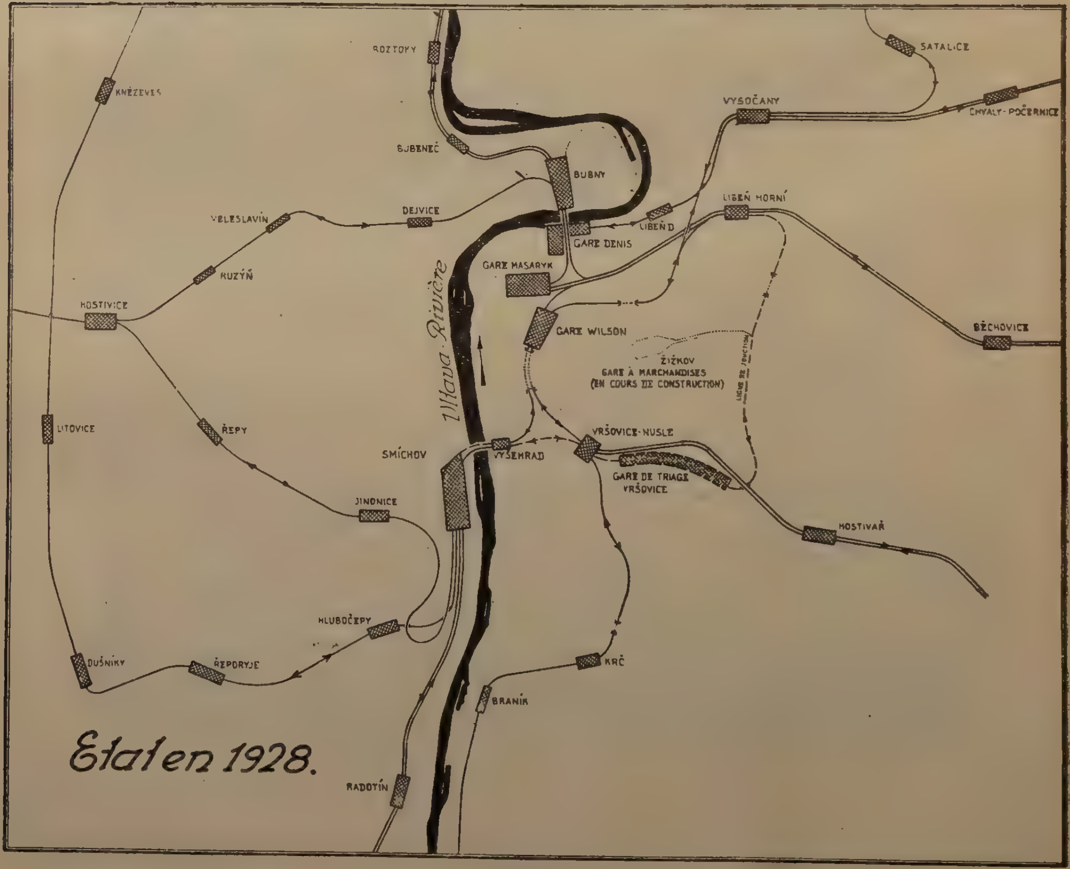


Fig. 13.

LEGEND : ▬▬▬ Mixed traffic; ┄┄┄┄ Goods traffic. Position in 1928.

per yard) rails for the 0.76 m. (2 ft. 6 in.) gauge.

Following the proposals of this programme a whole series of lines, notably the line from Praha to Česká Třebova, and beyond towards Olomouc and Košice respectively towards Brno and Bratislava (figs. 11, 12) have already been strengthened.

5. — *Layout of the stations at Prague* (¹).

At Prague (Praha) the capital of the Czechoslovakian Republic, immediately after the war at the time when all the railways ending at that city had not been taken over by the State, the need for improving the layout of the railway stations and connecting lines made itself much felt.

It was the investigation into this question of the « Prague stations » that led to the large marshalling yard at Vršovice (see fig. 13) and the connecting railway — reserved for goods traffic only — from this yard to the station of Liben which was built soon after the world war. The question of improving the passenger stations was also taken into consideration but without leading to any definite result.

The revolution of 1918 brought with it new and energetic ideas and, above all, a larger and unified base upon which to solve the problem. As capital of an industrial and agricultural State of thirteen and a half million inhabitants, situated in the centre of Europe, Prague acquired a much greater importance and its development became quicker and greater. These radical changes in the conditions of the city required an entirely new solution of the question. The preliminary investigations were handed over to a designing office formed by the State Railways administration and which functioned in accordance with a special law, in conjunction with the State Commission of Control for the city of Prague, a corporation created with a view to the carrying out of the plan for the laying out and construction of the capital of the Republic.

The schemes for the stations were also submitted to a larger Committee composed of public organisations interested in the remaking of the stations and known as the « Commission for the Prague stations »; later on was formed a smaller Committee called the « Working Committee for the Prague stations » composed of representatives of the Polytechnical Schools, of the Ministry of Public Works, of the Masaryk Trade Academy, of the town planning Commission, etc.

It is generally known that the solution of the questions affecting the principal stations of large cities demands very lengthy preparatory investigations. In the same way at Prague the working out of the scheme came up against many difficulties, and it was necessary to bring into line many conflicting points of view, amongst others the point of view of the operation of the railways with matters concerning the general layout of the city. The point of view of the town planning plan, as well as the railway programme, is that Prague, which now has 750 000 inhabitants, will become in the near future a large modern city with a million and a half inhabitants. Thanks to the efficacious co-operation of the authorities concerned, it has been possible in a relatively short period of time, to arrive at a definite solution. The arrangement of the stations has been included in the

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(¹) From information given by the Railway Designing Office at Prague.

town planning of the city as drawn up by the Town Planning Commission. This fact is one of great importance for the progressive arrangement of the stations, seeing it assures to the railways the acquisition of the necessary land, which for the future is not available for any buildings or other purposes other than those laid down in the town planning scheme.

In August 1928, the question of the Prague stations began to enter the construction stage by the taking in hand of the building of the new « Žižkov » goods station. This station, part of the future railway layout, is a preliminary step in order to make it possible to proceed with the re-arrangement of the passenger stations in the centre of the city, that is to say, the preliminary removal of the goods side from these stations and the subsequent extension of these stations for passenger services.

The plan of layout for the whole of the rebuilding considered was the result of a detailed analysis of the traffic conditions at Prague on the basis of the statistical data of the pre-war and post-war periods, as well as of the expected growth of traffic. The layouts proposed have been compared with the railway plans carried out or proposed in large foreign cities, the density of passenger and goods traffic in these cities being taken into account. In its principal lines, the scheme for the layout of the Prague stations can be characterised as follows. In principle, the goods traffic is separated from the passenger traffic on arrival at the outskirts of the city by supposing four marshalling yards, each connected with each of the goods stations situated either near the centre of the city or its boundaries. The passenger traffic is divided into long distance traffic, local traffic and suburban traffic (up to 25 to 30 km. == 16 to 19 miles) from Prague. The whole passenger traffic is concentrated on the Wilson Station equipped to deal with more than 1 300 trains per 24 hours on 15 platform lines. These figures do not include the suburban trains running over special suburban lines with entirely separate platforms. The suburban trains can be run at very short intervals (1 m. 40 s. minimum).

As will be seen from figure 14, the scheme provides for two groups of carriage sidings as close as possible to the Wilson station. This station when completed will represent the type of through station layout on the principle of working by directions. In this arrangement, a relatively restricted number of platform lines is sufficient for the large number of trains provided for under the scheme. The passenger trains from all directions continue, after a short stop at the station, their journey to the empty carriage sidings. All shunting with the rakes of stock forming these trains, as well as cleaning and other repair work, is transferred to these sidings. The only trains not sent on are the direct international and de luxe trains, which are few in number.

The solution adopted has another valuable feature. It has actually been possible to place the main station for the express parcels and postal services in close proximity to the passenger station, the passenger service being closely bound up with the express parcels service.

The interest, not only of the city of Prague but of the entire country, urgently requires that the reconstruction work on the Prague stations, carefully considered during the first decade of existence of the Czechoslovakian State Railways administration should be carried out so as to make good in as short a time as pos-

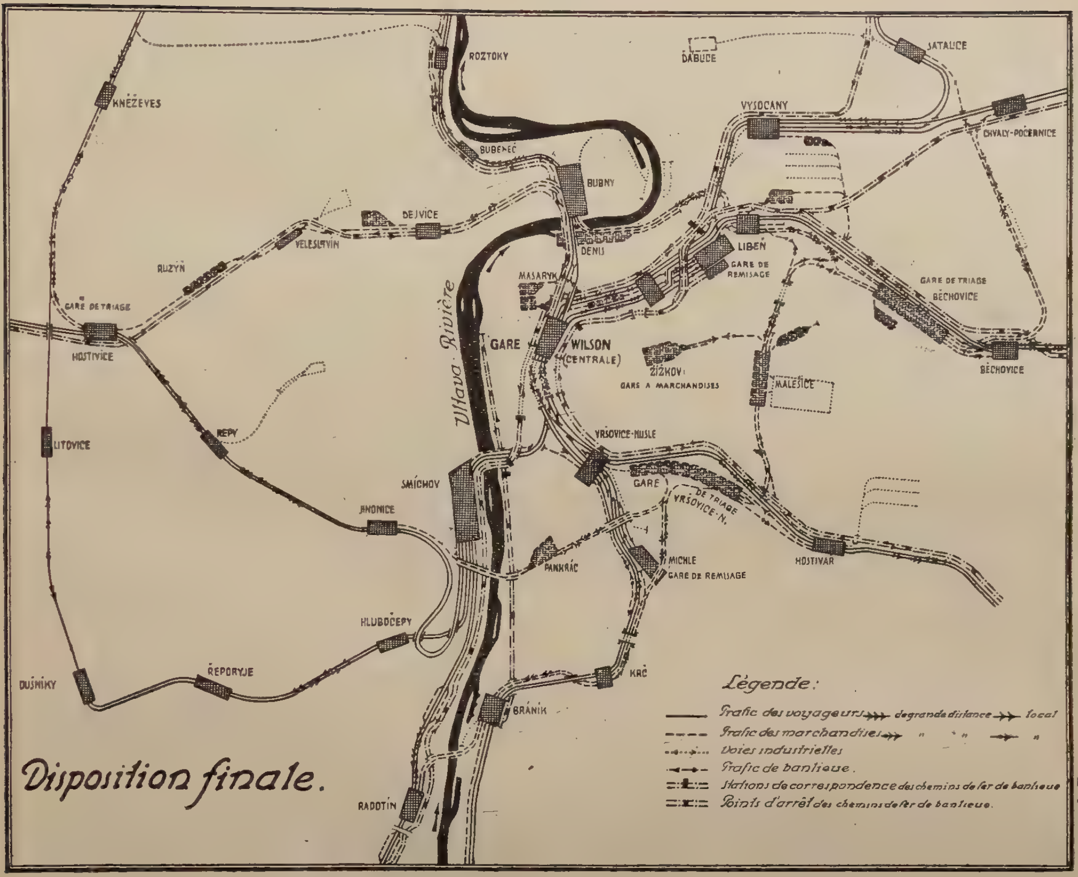

Fig. 14.

LEGEND :

——— Passenger traffic →→→ long distance —→→ local.
—·—·— Goods traffic —·→→ long distance —·→ local.
·←··· Industrial lines.
←—·— Suburban traffic.
═╪═ Exchange stations of the suburban lines.
═╪═ Stopping places of the suburban lines.
Disposition finale = Final layout..

sible the present inadequate railway facilities at Prague, and to facilitate the progressive development of the city and its commercial life.

Problems similar to those of Prague though smaller in scale have arisen in connection with the stations of the cities of Brno, the capital of Moravia, and Bratislava, capital of Slovakia. The work of reconstruction of these stations has already been taken in hand.

6. — *Repurchase of private railway companies.*

The major part of the railways on the present territory of the Czechoslovakian State immediately before the war was in the hands of the State; there were none the less a certain number of private railway companies having two main characteristics :

1. Light railway systems, which, owing to their location, interfered with the State railways;

2. Light railways which, as a result of the war, had become unused. Seeing that these lines were lines for which the interest on the capital was guaranteed by the provinces or by the State, they were a serious financial burden for the public bodies concerned.

If, on the one hand, it was necessary for the proper development of the State system to repurchase the private light railways, such as the Košice-Bohumín (628 km. = 390 miles) line forming part of the principal arterial line of the Republic or the Ustí Teplice (250 km. = 155 miles) and the Buštěhrad (419 km. = 260 miles) lines of considerable importance in the transport of coal from the lignite field in the North of Bohemia, on the other hand, financial reasons equally demanded that the State should take over light railways out of use.

The State Administration has carried out these two duties in the greater part during the last ten years.

The State Railway Administration completed in this way the work of nationalisation of the former Austro-Hungarian State, a work far advanced at the Revolution and the beginnings of which dated back to 1870-1875.

As from the 1 January 1921, the State resumed the operation of the Košice-Bohumín railway in conformity with the terms of law No. 690/1920.

Amongst the light railways nationalised were the Užhorod-Vajany line (1920), Rakovnik-Louny line (1922), Počeradce-Vrskmany (1923), Holič-Hodouin, Borža Valley, Kúty-Frontier lines (1924).

In 1924, were nationalised the two principal railways remaining in Bohemia, namely, the Usti-Teplice and the Buštěhrad lines.

The nationalisation had to be done in accordance with a definite programme, taking into account the judicial and financial conditions of the pre-war railways, and primarily those of the railways operated by the State.

The Government decree of the 22 May 1924 required all secondary railways then to the number of 128 to be nationalised in turn, in three stages, the first being formed of the light railways guaranteed by the State (16), and by Bohemia (32); the second, of the light railways in Slovakia, and finally, the third, of all the other private light railways in Bohemia, Moravia and Silesia.

In 1925, the first stage, 48 light railways were nationalised. The length of these lines operated amounted to 1 860 km. (1 156 miles) and their capital to 217 million crowns.

The second part of the programme had already been taken in hand by nationalising the light railways in Slovakia; the work is now in hand. The second stage is more difficult than the first, chiefly due to the diversity of the conditions, both judicial and financial, of the Slovakian light railways. This is the reason why their nationalisation is prepared by means of the successive repurchase of the priority stocks.

In this way, the preference shares of twelve Slovakian private railways of a total length of 526 km. (327 miles) passed into the hands of the State.

As soon as the Slovakian railways are nationalised, the third stage will be taken in hand, that is to say, the nationalisation of the railways remaining in Bohemia and in Moravia will take place as soon as possible, for insistent reasons.

In this way in the near future, the whole of the railway system in Czechoslovakia will be, with few exceptions, in the possession of the State Railway Administration.

C. — **Rolling stock.**

1. — *Rolling stock position at the Revolution.*

In former Austrian times, on the 14 140 km. (8 786 miles) of line operated by the State, the stock at the end of 1913 consisted of 5 659 locomotives, 10 712 carriages and 109 775 wagons, that is to say, for every 100 km. of line operated, 40 locomotives, 77 passenger carriages and 775 goods vehicles (64 locomotives, 124 carriages and 1 247 wagons per 100 miles).

On the territory of the Czechoslovakian Republic, there were at the end of the year 1919, on 11 404 km. (7 086 miles) operated, 3 424 locomotives, 6 346 carriages, and 64 845 wagons. This was equivalent to 30 locomotives, 55 carriages, and 568 wagons per 100 km. (48 locomotives, 89 carriages and 914 wagons per 100 miles) operated. The comparison of these figures shews the sortage of rolling stock on the Czechoslovakian Railways at the Revolution. Moreover, this numerical insufficiency was still further, and to a large extent, increased by the bad condition of the stock, which resulted in a large number of vehicles being out of service for repairs. This was especially so in the case of goods vehicles with which the difficulties, due to the before-mentioned causes, threatened to become catastrophic as a result of the failure to carry out the regulations concerning the condition of ownership of the vehicles of the former Austro-Hungarian Railway system. The first really authentic statistics as to the number of vehicles in Czechoslovakia were obtained from the census of vehicles made the 15 March 1919. According to this census, there were in the Republic :

40 147	goods wagons formerly belonging to the Austrian system;
19 585	goods wagons formerly belonging to the Hungarian system;
59 732	in all.

At the census of the 11 October 1919, the following wagons only were recorded:

30 090	wagons of the former Austrian Railways;
23 750	wagons of the former Hungarian Railways;
53 840	in total.

Consequently, at this time Czechoslovakia lost on the average nearly 1 000 wagons per month, which after crossing the frontier of the Republic never returned to it.

The Czechoslovakian Railway Administration obviously took every step in its power to put an end to this critical state of affairs. A remedy was to be found especially in two directions :

1. By negotiating with the new States formed from the former Austro-Hungarian Empire the bases of a new judicial agreement relating to the ownership and the interchange of vehices formerly belonging to the Austro-Hungarian Railways;

2. By increasing the rolling stock park of the Czechoslovakian Railways by building new vehicles, and by other means.

During 1919, provisional agreements were concluded with some States on the question of the return of rolling stock.

In October 1919, a Commission was

formed for the distribution of the rolling stock of the former Austro-Hungarian State Railways, in accordance with article 318 of the Saint-Germain Peace Treaty and the analogous clause of the Trianon Peace Treaty. This Commission sat at Vienna. At the end of the year 1920, a Committee nominated by the Peace Conference met at Vienna to deal with the circulation of vehicles in central Europe, the task of this Committee being to facilitate the traffic between the Successor States whilst waiting for the rolling stock park of the former Austro-Hungarian State Railways to be definitely allocated, and especially to remedy the difficulties arising from the interchange use of the goods vehicles.

Although the work of these Commissions may not have immediately solved the questions arising from the distribution and circulation of the vehicles, it certainly prepared the ground by bringing together the points of view of each of the States, so that during the first half of the year 1921 the first definite partial distribution of the stock of goods wagons of the Austrian State took place, and in November of the same year the agreements of Portorosa were concluded, by which was introduced as from the 1 January 1922 the new regulation on the non-allocated portion of the vehicles of the common Austro-Hungarian park. From this date this park ceased to exist so far as its circulation between the Successor States and abroad : the vehicles of the former Austro-Hungarian park were provisionally painted with the marking of the Successor State.

At Portorosa the question of regulations for private owners' wagons was also settled.

Similarly, other questions relating to the allocation and circulation of the vehicles were settled in turn, and in particular by the definite allocation of the rolling stock by the labour of the Allocation Commission of 1925 and, thanks to the conclusion of new European agreements dealing with the use of the wagons, a normal state of affairs was re-established.

2. — *Construction of new vehicles.*

The efforts of the Railway Administration of the Czechoslovakian State with regard to the building of new rolling stock during the first ten years of the Republic's existence when the shortage of stock was most critical are made evident by table B.

TABLE B.

New vehicles acquired during the years 1919 to 19 2.

NEWLY ACQUIRED.	During the year				Total during four years
	1919	1920	1921	1922	
Locomotives	90	116	100	49	355
Passenger vehicules	413	306	359	22	1 100
Brake vans	109	100	481	58	688
Post office vans	9	...	13	...	22
Goods wagons	8 890	14 436	9 265	1 345	33 936

So that during the four years it acquired about 350 locomotives, more than 1 800 passenger carriages, brakes and postal vans, and, above all, 34 000 goods wagons.

It was in this manner that the number of vehicles grew to the point at which the great shortage of the early days was overcome.

The increase in the rolling stock was continued subsequently but at a more moderate rate, and after the final allocation of rolling stock by the Commission, the condemning of the least useful and most expensive vehicles, worn out and not suitable for present requirements, was taken in hand.

The number of locomotives as from the year 1923, when the maximum was reached, has steadily fallen. None the less, as the new locomotives are more powerful and more economical than those condemned, in spite of the numerical decline, the work done by the locomotive stock of the Czechoslovakian State railways is continuously increasing. A new locomotive replaces in operation one and a half of the old engines.

During the period 1924 to 1928, at least 120 old locomotives have been condemned annually on the average, whilst the number of new engines acquired each year has only averaged 55. Seeing that during this period the number of locomotives under repair continually diminished, the growing demands of the traffic were met without difficulty. In the same way, the quality of the wagon stock has steadily improved, both as regards useful load and size, although the number of goods wagons declined. The evolution of the Czechoslovakian State Railways' rolling stock is shewn by table I.

3. — *New types of steam locomotives.*

In view of the increased weight of all trains, the Czechoslovakian State Railways have been obliged to build some new types of locomotives suitable to the existing conditions on the Czechoslovakian Railways. These lines are built for the most part in hilly districts and had to comply with the configuration of the country, so that there are very many gradients. Of the total of 13 118 km. (8 151 miles) of lines operated by the Czechoslovakian Railways, at the end of 1926, only 21.85 % were on the level, whilst 35.05 % had gradients of 0.5 % : 18.88 % gradients of 0.5 to 1.0 %; 22.72 % gradients of 1.0 to 2.5 %, and 15 % gradients above 2.5 %.

Another feature of the Czechoslovakian railway system, which has already been mentioned, is its relatively light permanent way.

The fuel used by the locomotives is largely lignite produced in the Duchcov-Most basin having a calorific value of 4 000 to 5 000 calories (16 000 to 20 000 British thermal units), in part also Silesian coal (from Moravská-Ostrava) rather fusible having a heat value of about 5 000 calories (20 000 British thermal units). In addition to these main sources of supply of fuel, other kinds of coal from many fields of less importance throughout the Czechoslovakian Republic are used.

The locomotives designed by the Czechoslovakian State Railways administration recall the old types in use on these railways before the war : care was of course taken to improve them by using new equipment which has given good results in locomotive work. The Czechoslovakian administration has endeavoured to build types of locomotives as simple as possible, so as to ensure the cost of repair being as low as possible. The new types have also kept in mind the advantages to be obtained by the standardisa-

TABLE C.

New types of locomotives of the Czechoslovakian State Railways.

Class.	365.0	387.0	386.0	445.1	423.0	446.0	534.0
Type	1 C 1	2 C 1	2 C 1	1 D	1 D 1	1 D 2	1 E
Adhesive weight, metric (English) tons	45.2 (44.5)	50.2 (49.4)	48.0 (47.2)	61.2 (60.2)	49.2 50.0 (48.4) (49.2)	60.1 (59.2)	71.50 (70.4)
Weight empty, metric (English) tons	65.8 (64.8)	81.0 (79.7)	77.17 (75.9)	67 (65.9)	51.4 52.0 (50.6) (51.2)	81.0 (79.7)	73.0 (71.8)
Weight, working order, metric (English) tons	72.9 (71.7)	89.6 (88.2)	88.14 (86.7)	75.1 (73.9)	69.8 70.8 (68.7) (69.7)	107.35 (105.6)	83.27 (81.9)
Maximum speed, km. (miles) per hour	90 (56)	110 (68)	110 (68)	70 (43)	50 (31)	70 (43)	60 (37)
Steam pressure, kg. per cm² (lb. per square inch.)	13 (199)	13 (185)	14 (199)	13 (185)	13 (185)	13 (185)	14 (199)
Grate area in m² (square feet)	4.0 (43.0)	4.8 (51.7)	4.57 (49.2)	4.4 (47.4)	2.06 (22.2)	4.4 (47.4)	4.2 (45.2)
Firebox heating surface, water side, m² (square feet)	13.5 (145.3)	17.5 (188.4)	19.4 (208.8)	14.43 (155.3)	9.2 (99.0)	14.48 (155.9)	15.5 (166.8)
Heating surface of tubes, water side, m² (square feet)	214.1 (2 304.6)	242.5 (2 610.3)	227.5 (2 448.9)	201.22 (2 166.0)	113.4 (1 220.7)	102.62 (1 104.6)	202.67 (2 181.6)
Total heating surface, m² (square feet)	227.6 (2 444.1)	260 (2 798.7)	246.9 (2 657.7)	215.65 (2 321.3)	122.60 (1 319.7)	217.10 (2 336.9)	218.17 (2 348.4)
Heating surface of superheater, m² (square feet)	44.5 (479.0)	93 (1 001.1)	89.3 (961.3)	55.65 (599.0)	35.24 (379.3)	82.88 (892.1)	53.0 (570.5)
Diameter of driving wheels (50 mm. (2-inch.) tyres, in mm. (in feet and inches)	1 780 (5 ft. 10 1/16 in.)	1 900 (6 ft. 2 13/16 in.)	1 850 (6 ft. 13/16 in.)	1 575 (5 ft. 2 in.)	1 100 (3 ft. 7 5/16 in.)	1 575 (5 ft. 2 in.)	1 260 (4 ft. 1 9/16 in.)
Diameter of bogie wheels in mm. (in feet and inches)	...	994 (3 ft. 3 1/8 in.)	994 (3 ft. 3 1/8 in.)	...	...	994 (3 ft. 3 1(8 in.)	...

Diameter of trailing carrying wheels in mm. (in feet and inches) . . .	994 (3 ft. 3 1/8 in.)	1 258 (4 ft. 1 1/2 in.)	1 258 (4 ft. 1 1/2 in.)	995 (3 ft. 3 1/8 in.)	830 (2 ft. 9 1/16 in.)	994 (3 ft. 3 1/8 in.)	994 (3 ft. 3 1/8 in.)
Number and diameter of cylinders in mm. (in inches).	2 × 570 (2 22 7/16 in.)	3 × 525 (2 × 20 11/16 in.)	3 × 525 (2 × 20 11/16 in.)	2 × 600 (2 × 23 5/8 in.)	2 × 480 (2 × 16 3/16 in)	2 × 600 (2 × 23 5/8 in.)	2 × 620 (2 × 24 3/8 in)
Stroke of pistons in mm. (in inches).	680 (26 13/16 in.)	680 (26 13/16 in.)	680 (26 13/16 in.)	720 (28 3/8 in.)	570 (22 7/16 in.)	720 (28 3/8 in.)	632 (24 7/8 in.)
Date first engine delivered	1921	1926	1927	1924	1921	1928	1923
Builders.	Českomoravská, Co., Praha.	Škoda Co., Plzeň.	Škoda Co., Plzeň.	Českomoravská Co., Kolben Co., Praha.	Českomoravská Co., Kolben Co., Praha.	Českomoravská Co., Kolben-Daněk Co., Praha.	Škoda Co., Plzeň Breitfeld. Daněk & Co., Praha.
Figs	15	16	...	...	17	20	19

tion of the greatest possible number of detail parts.

Compound steam locomotives have been given up completely; on the other hand, superheating has been introduced generally. As superheater, the Schmidt superheater with small diameter tubes has been used in preference. The efficiency of the locomotive has also been increased in part by heating the feed water by the Metcalfe method, which uses the heat as well as the kinetic energy of the exhaust steam; in part, by means of a series of constructional details such as the piston valves having inside admission, narrow rings on the pistons and piston valves, with special gland packing for superheated steem, by pump lubrication, not only for the pistons but also for the axle boxes, and feed water purifiers of Czechoslovakian manufacture (Vesely system), etc.

The leading dimensions of the new locomotives built during these last ten years by the Czechoslovakian State Railways Administration are given in table C (figs. 15, 16, 17, 18, 19 and 20).

All the locomotives, and similarly the tenders, are numbered in accordance with a simple system. For example, the number 365.035 designates a six-wheels coupled locomotive of a maximum speed of 90 km. (10 × [6+3]), of a maximum pressure of 15 (5+10)(*) kgr. on the driving wheels, a locomotive belonging to building class 0, and carrying the numerical number of 35. Similarly, the number of the class of tender indicates the coal and water capacity.

4. — *Electrification.*

Until quite recently only a few electrified lines of secondary importance

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(*) To the second figure 3 is added and the result multiplied by 10, to the third figure 10 is added.

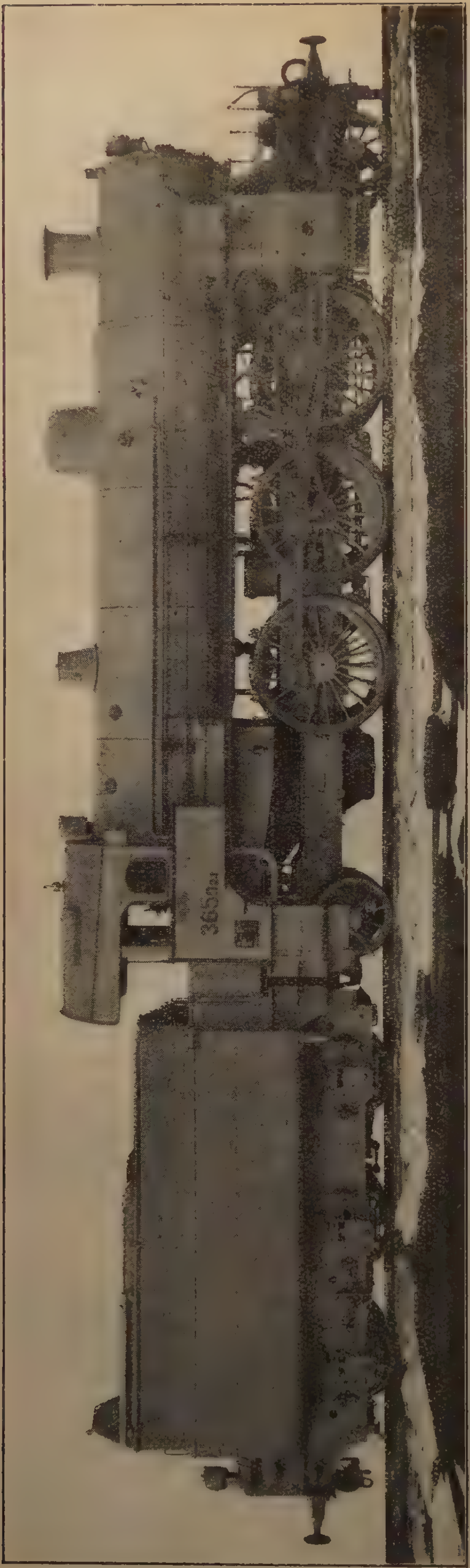

Fig. 15. — 1 C 1 locomotive, class 365.0, of the Czechoslovakian State Railways, built by the Českomoravská-Kolben-Daněk Company, at Prague.

existed in Czechoslovakia. In Bohemia there were two standard gauge light railways; that of Tábor-Bechyné 24 km. (15 miles) long, dated from 1903, and of Certlov-Lipno, 23 km. (14 miles) long, from 1911. In Slovakia, the Tatra Railway 35 km. (22 miles) long, narrow gauge, dating from 1912. All these railways used high tension continuous current (Tábor-Bechyné 2 × 700 volts, Certlov-Lipno 1 200 volts, the Tatra Railway 1 500 volts).

The first step towards the electrification of the main lines was only made recently by the electrification of the principal station in Prague, the Wilson station, and the adjoining sections leading to the four neighbouring stations in the suburbs of Prague. This electrification was made necessary, not only for railway reasons with a view to reducing the traffic through the long 1 000-m. (1 094 yards) tunnel at the South end of the Wilson station, a tunnel in which the density of traffic is due in large part to the movements of light engines returning to the shed beyond the tunnel : the electrification was also demanded by the requirements of the City, especially for hygienic and artistic reasons with a view to getting rid of the smoke nuisance.

The electric power is supplied by the electric generating stations of the City of Prague. These undertakings are linked up by a 100 000-volt line to the steam driven power house at Ervenice : in addition, they have a steam power house at Praha generating 30 000 kw. as a stand-by. The station next in importance to the Wilson is connected by two 22 000-volt lines, in part to the transformer station, and in part to the urban distribution system.

The secondary station possesses a group of transformers of 1 000 kw. and a second

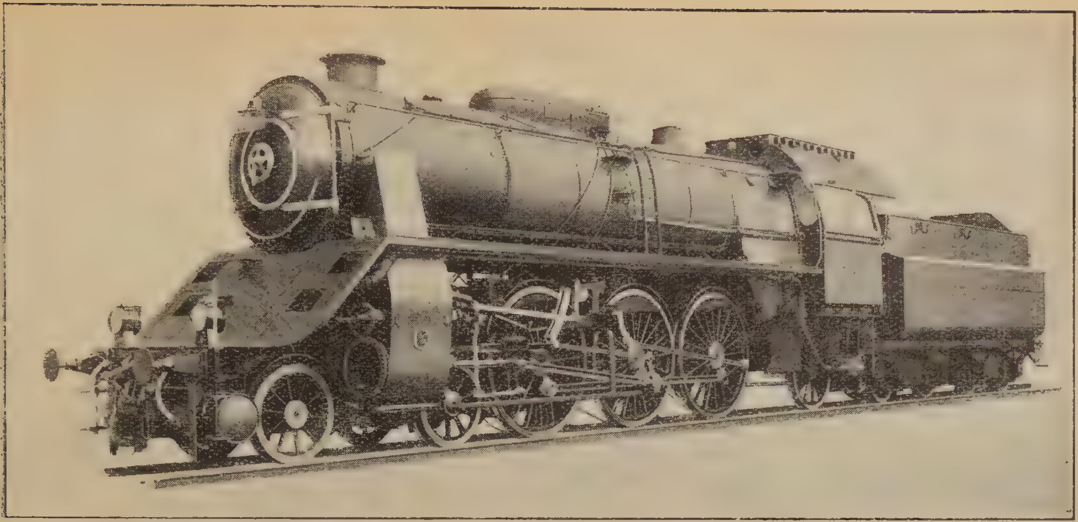

Fig. 16. — 2 C 1 locomotive, class 387.0 of the Czechoslovakian State Railways, built by the Škoda Company at Plzeň.

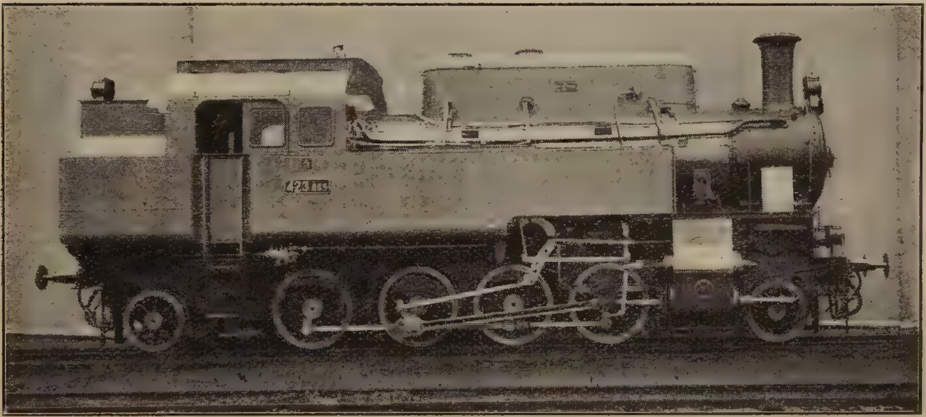

Fig. 17. — 1 D 1 locomotive, class 423.0, of the Czechoslovakian State Railways, built by the Škoda Company at Plzeň.

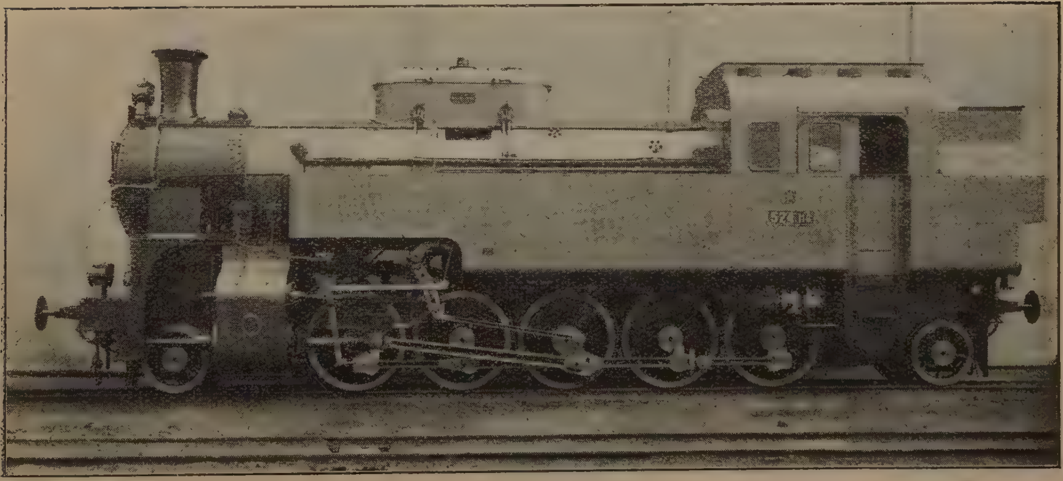

Fig. 18. — 1 E 1 locomotive, class 524.1, of the Czechoslovakian State Railways, built by the Škoda Company at Plzeň.

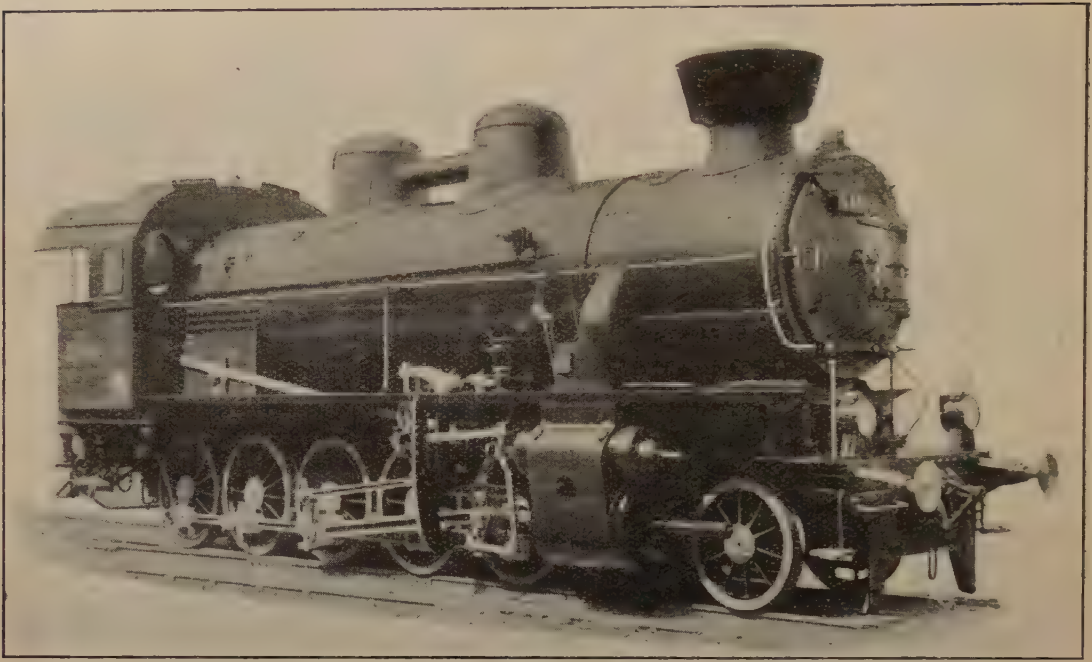

Fig. 19. — 1 E locomotive, class 534.1, of the Czechoslovakian State Railways, built by the Českomoravská-Kolben-Daněk Company, at Prague.

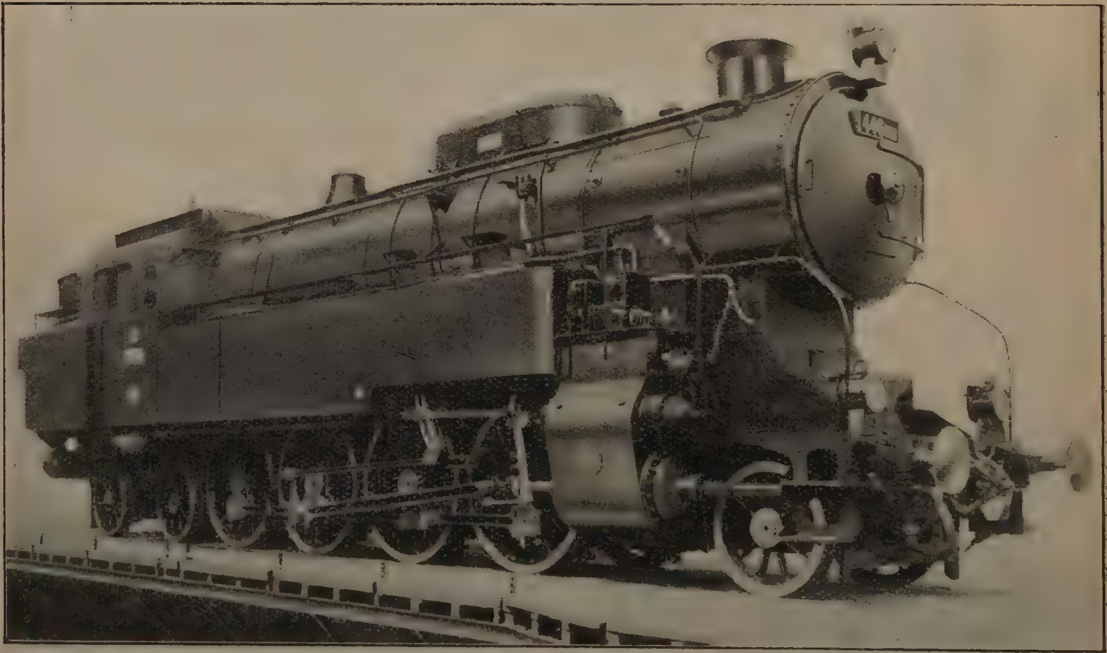

Fig. 20. — 1 D 2 locomotive, class 446.0, of the Czechoslovakian State Railways, built by the Českomoravská-Kolben-Daněk Company, at Prague.

of 2 000 kw. of the Westinghouse system, made by the Czecho-Moravian Works of Kolben-Breitfeld. In addition, in order to complete this station, a mercury rectifier of 4 300 kw. capacity has been ordered. The alternating current at 22 000 volts is transformed to low tension and is rectified into continuous current at 1 500 volts which is distributed by overhead line along the electrified section (fig. 21).

The construction of the overhead line was given to four firms, each having a different trolley system, namely, the **Křižik Company**, the **Czecho-Moravian-Kolben-Breitfeld, Co.**, the **General Electric Company** (the A. E. G.), and the **Škoda Company**.

For the trolley, the section standardised is 100 mm^2 (0.155 square inch) with a minimum strength of 3 650 kgr. (8 047 lb.). Along the track, two trolley lines are prescribed, the conductibility of which is increased by a carrying wire and by a strengthening wire in copper of 360 to 400 mm^2 (0.548 to 0.620 square inch) cross section. The height of the trolley line is in the stations 6.20 m. (20 ft. 4 in.) above the rail and along the track 5.70 m. (18 ft. 8 1/2 in.).

At the end of 1925, orders were placed with Czechoslovakian firms who collaborated with foreign firms having special experience in electrification questions, for 16 new electric locomotives, 5 for express trains, 5 for goods trains, and 6 for shunting purposes. The principal dimensions of these locomotives are given in table D.

TABLE D. — **Electric locomotives.**

Figure.	Number.	CLASS AND KIND.	Type.	Adhesive weight in metric (English) tons.	Total weight in metric (English) tons.	Number of motors.	Power at the hour rate, in kw.	Speed in km. (in miles).		Supplied by : a) = Electric part. b) = Mechanical part.
								Normal.	Maximum.	
24	2	E 465.0. Stopping.	1-4 A-1	64 (63.0)	78 (76.8)	4	1 460	50 (31)	90 (56)	a) Křižik BBC. b) Breitfeld-Daněk.
26	3	E 466.0. Stopping.	1-4 A-1	64 (63.0)	84 (82.7)	4×2	1 600	50 (31)	90 (56)	a) b) Škoda.
22	1	E 466.1. Stopping.	AA-AA	64 (63.0)	64 (63.0)	4	1 300	50 (31)	90 (56)	a) b) Č. M. Kolben and Westinghouse.
	4	E 436.0. Goods . .	AA-AA	64 (63.0)	64 (63.0)	4	1 300	30 (19)	50 (31)	
25	2	E 424.0. Shunting.	B-B	54 (53.1)	54 (53.1)	2×2	800	30 (19)	50 (31)	a) b) Škoda.
—	2	E 424.1. Shunting.	AA-AA	56 (55.1)	56 (55.1)	4	736	30 (19)	50 (31)	a) Siemens. b) Breitfeld-Daněk.
23	2	E 423.0. Shunting.	AA-AA	50 (49.2)	50 (49.2)	4	920	30 (19)	50 (31)	a) Metropolitan Vickers- London. b) Adamov.

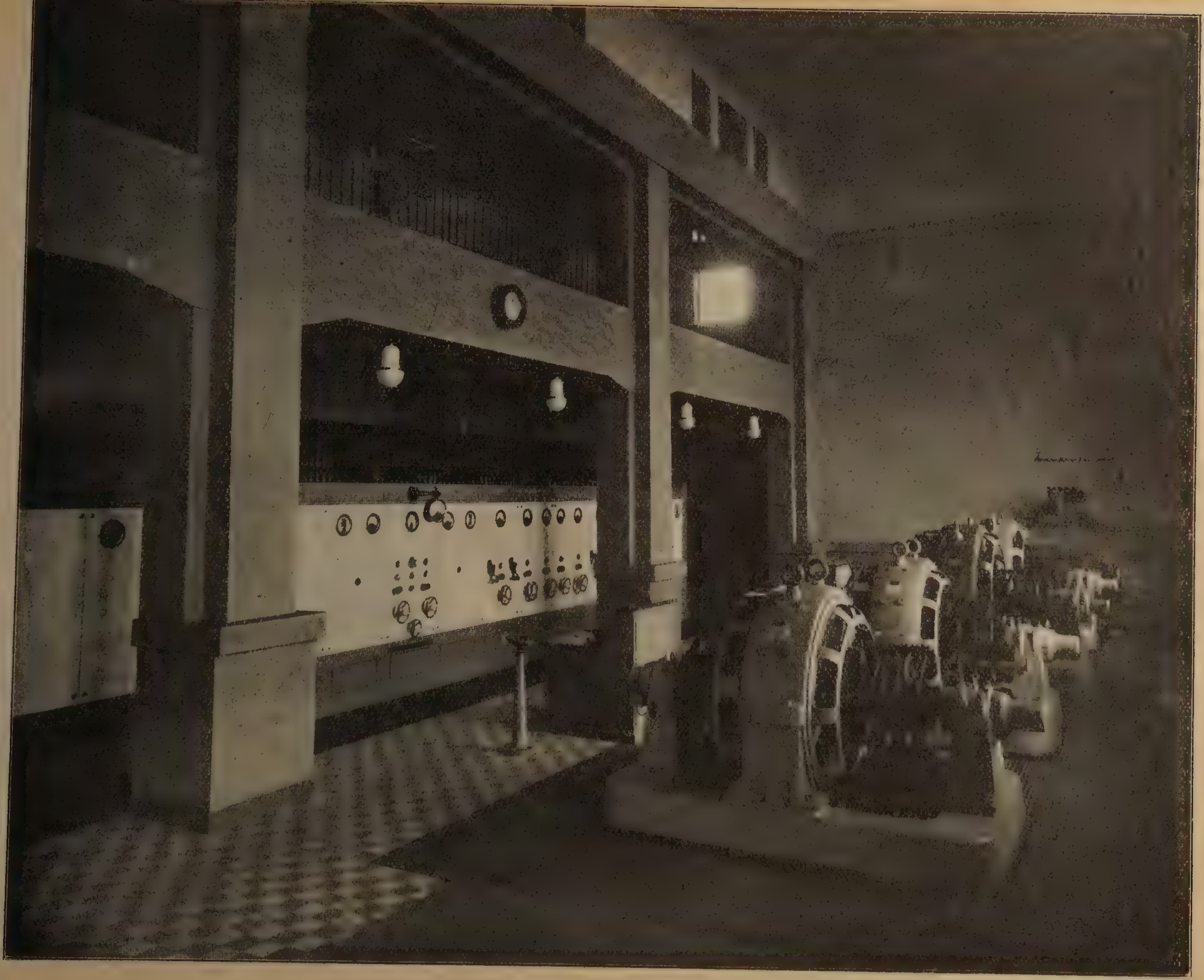

Fig. 21. — Transformer sub-station. — Interior.

All except two of the locomotives drive each axle independently, four locomotives have electro-magnetic control and 12 electro-pneumatic.

These locomotives were delivered at the end of 1927 and the beginning of 1928, so that on the 15 May electric traction over the two lines to the North of the Wilson station at Praha was inaugurated. During the year 1928, the operation to the South (figs. 22, 23, 24, 25 and 26) will also be inaugurated.

For marshalling purposes, in addition to the electric locomotives with overhead equipment, the accumulator locomotive supplied in 1926 by Breitfeld Daněk & Co. (mechanical part) and the Křižik Co. (electrical part), and partly in accordance with the design of the Swiss firm, Messrs. Brown-Boveri is used. The arrangement of the axles is shewn by the convention AA — AA. Its weight is 68 t. (66.9 English tons), the power of each of the 4 motors is 52 kw., the batteries have 238 cells and 440 volts with a capacity on the hourly rate of 392 ampere-hours. The maximum speed is 40 km. (25 miles) an hour. This locomotive has given good results. It is for the particular work in question more economical than a steam locomotive. During the year 1928, a second locomotive of the same type was ordered (fig. 27).

Up to the present no decision has been come to as regards the electrification programme. From experience abroad, electric traction shews itself particularly advantageous in the case of suburban lines which, on the outskirts of Prague, in comparison with other cities of Europe of equal importance, are not suitably equipped. For this reason, the electrification of some of the suburban lines will be taken in hand shortly.

5. — *Rail motor coaches.*

The Administration of the Czechoslovakian State Railways has under test on some of the light railways, rail motor coaches using internal combustion motors of 100 to 200 H. P. Up to the present 10 vehicles of five different systems are in service. From the experience so far obtained, the Czechoslovakian State Administration is endeavouring to decide upon the type of rail motor coach which meets in every way the requirements of a rationally handled traffic (fig. 28). The general introduction of rail motor coaches is hindered by the difficult permanent way conditions of many light railways, by the rush of passengers at certain hours of the day, especially the morning, in numbers exceeding the capacity of the motor vehicle or of the trailer vehicles that may be coupled to it, and, furthermore, through the need for carrying at the same time luggage, parcels and postal matter. For this reason, it has been necessary to restrict the use of rail motor coaches to those cases in which a thorough investigation into the matter demonstrates the real advantages of this method of working.

Recently a greater number of small rail motor coaches known as rail omnibuses have been ordered. The advantage of these vehicles is a relatively low dead weight, and consequently low first, operating, and maintenance costs. A large rail motor coach weighing 34 t. (33.5 English tons) can carry 74 persons seated, which corresponds to 460 kgr. (1 014 lb.) dead weight per passenger. A rail motor bus weighs 7 t. (6.88 English tons) and has 32 seats, or only 243 kgr. (536 lb.) dead weight per passenger. The price of a rail motor coach varies between 800 000 and 1 000 000 crowns : a rail motor bus costs between 150 000 to 180 000. The

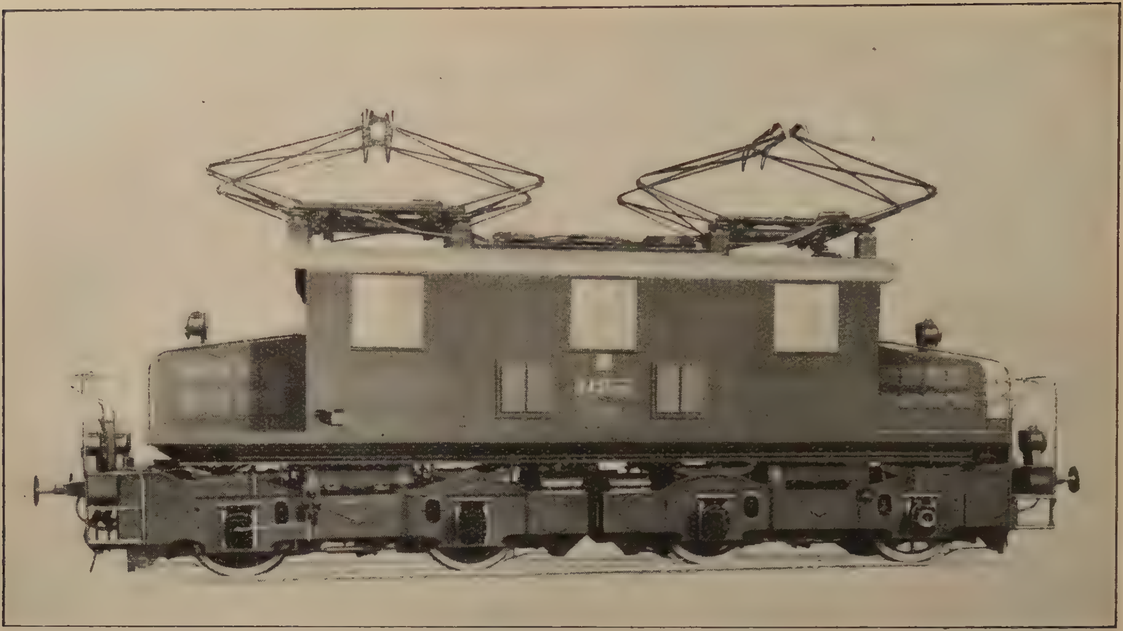

Fig. 22. — Electric locomotive, class E 436.0, of the Czechoslovakian State Railways, built by the Českomoravská-Kolben-Daněk Company, at Prague.

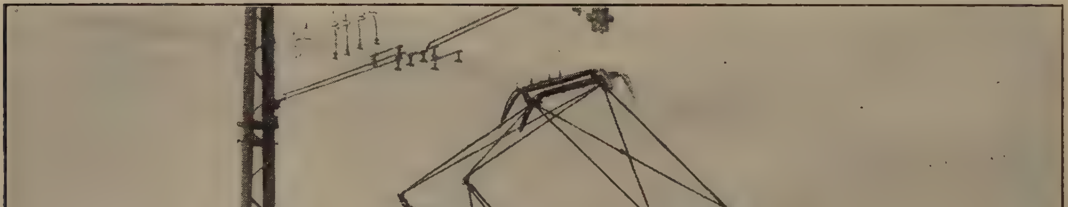

Fig. 23. — Electric locomotive, class E 423.0, of the Czechoslovakian State Railways, built by the Adamov Company.

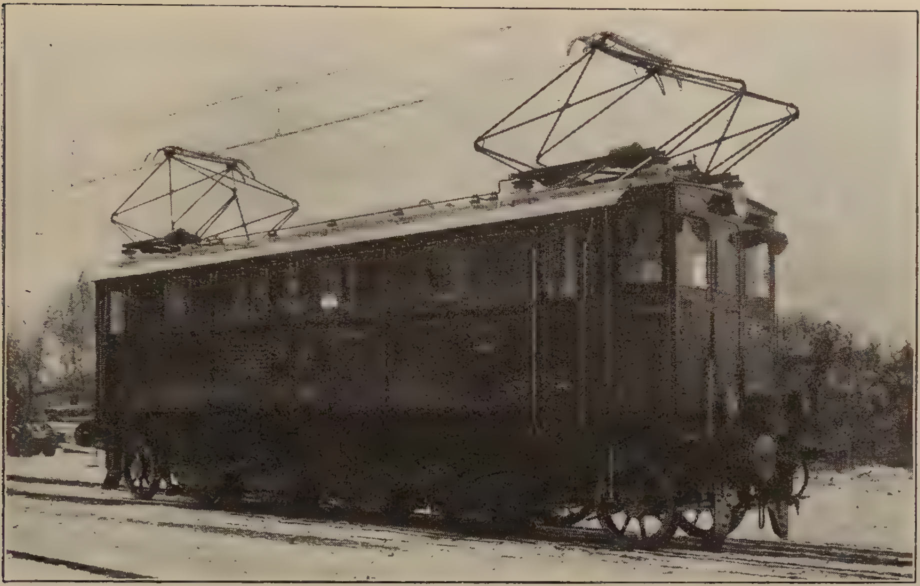

Fig. 24. — Electric locomotive, class E 465 of the Czechoslovakian State Railways, built by the Křížik and Breitfeld-Daněk Companies.

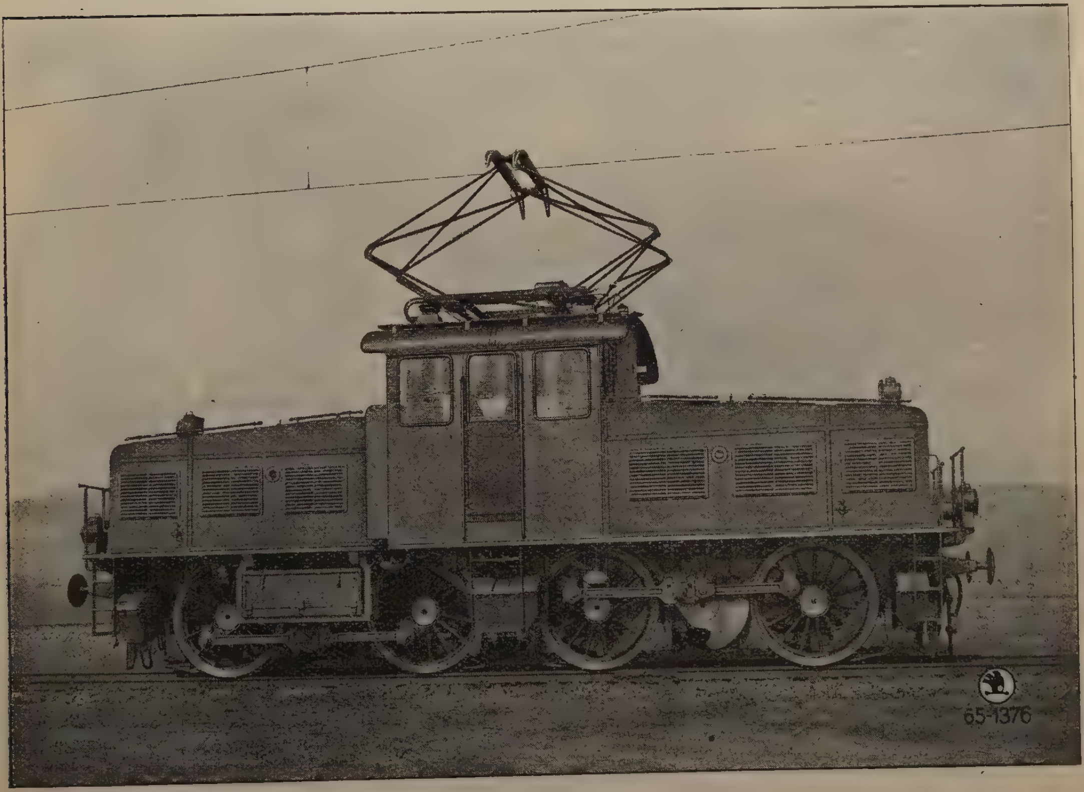

Fig. 25. — Electric locomotive, class E 424, built by the Škoda Company at Plzeň.

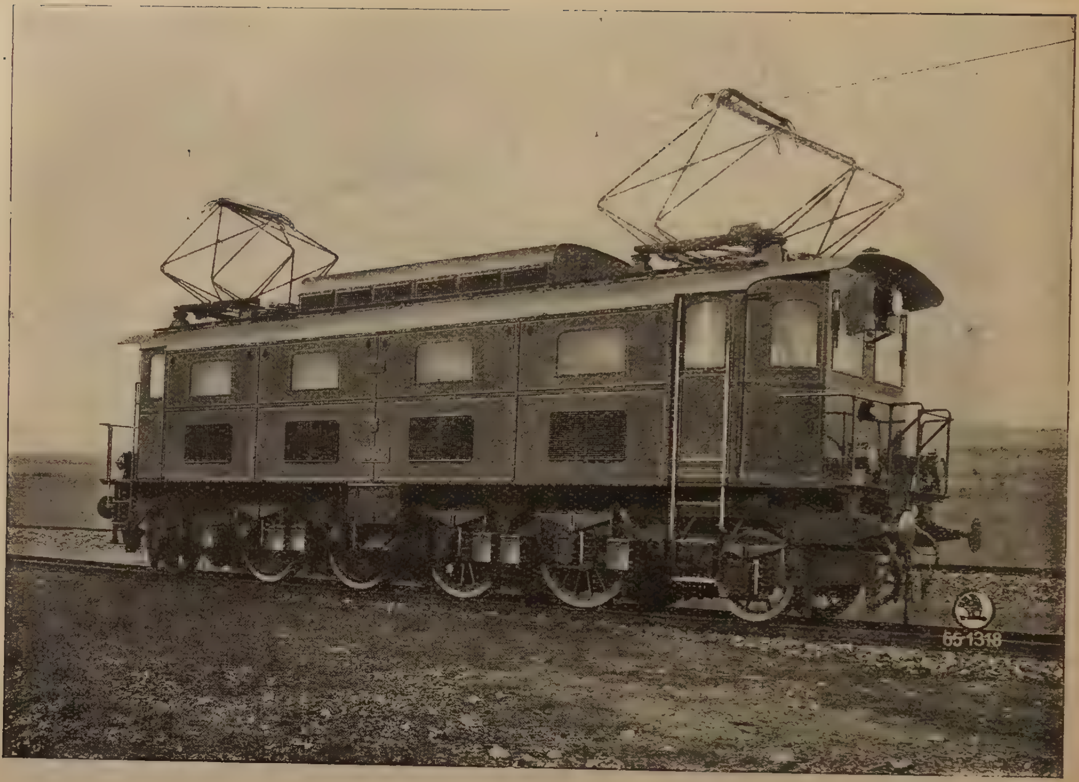

Fig. 26. — Electric locomotive, class E 466.0, built by the Škoda Company, at Plzeň.

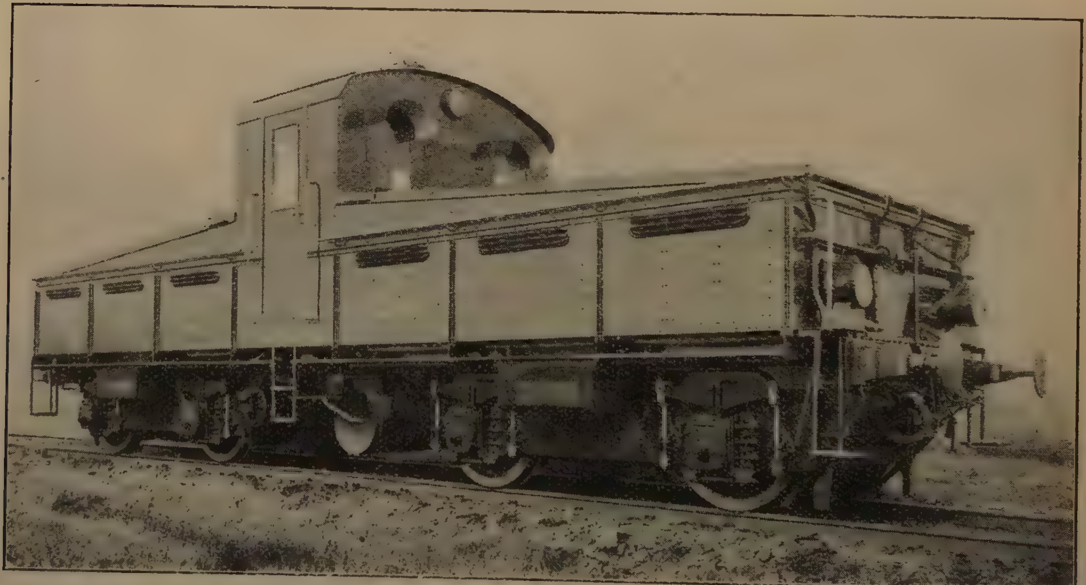

Fig. 27. — Accumulator locomotive for shunting, class E 407.0, of the Czechoslovakian State Pailways, built by the Českomoravská-Kolben-Daněk Company, at Prague.

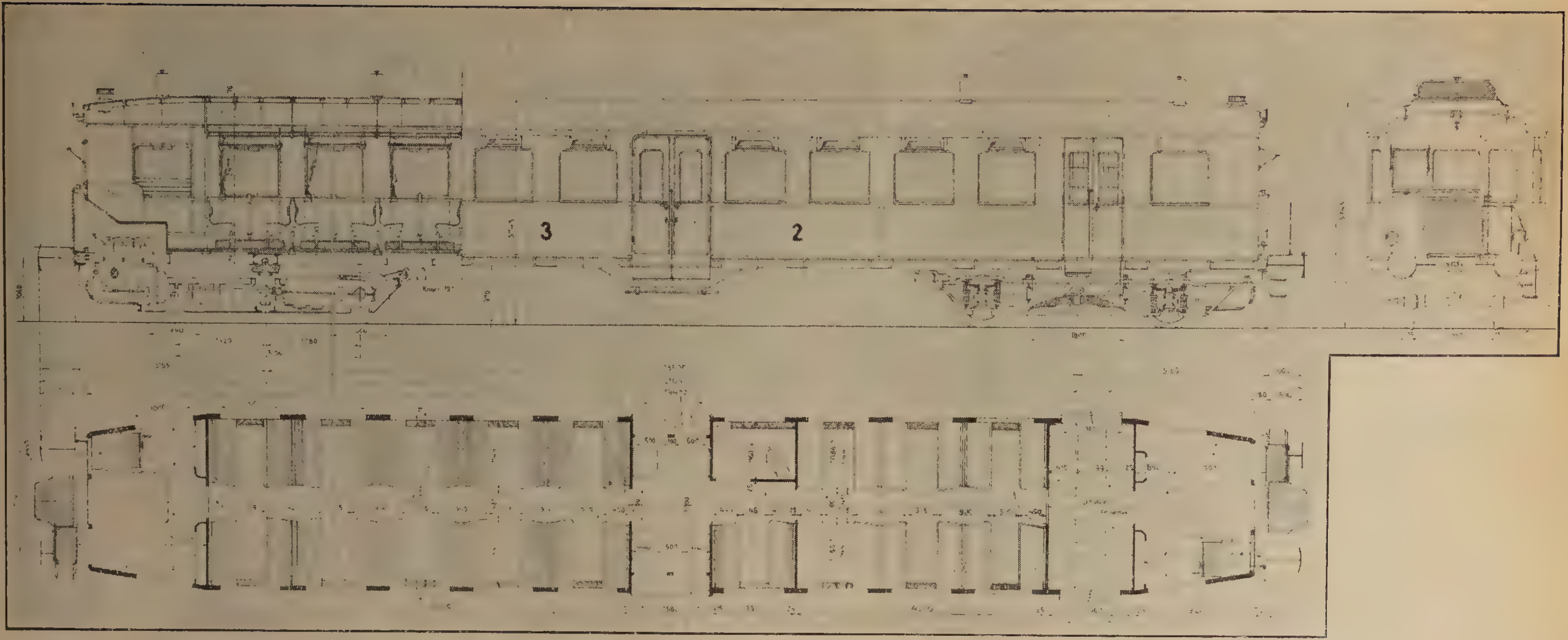

Fig. 28. — Petrol ((dynalcol) rail motor coach, IInd and IIIrd class, on four wheels, built by the Tatra Company at Kopřivniee, Moravia.

LEGEND :

Seats II. class	24	80
III. class	44	
Folding-up seats II)	4	
(III)	8	

2 Tatra motors	100 H. P.
Empty weight	34 t. (33.5 English tons).
Weight in working order	44 t. (43.3 English tons),
Maximum speed	80 km. (50 miles) an hour,

consumption of stores is for the rail motor bus only about one-fifth that of the rail motor coaches. It is also possible to reduce the staff of the rail motor bus to the minimum : a driver by himself can if need be issue and check the tickets, as is done in the case of road motor buses.

These vehicles ought to be used primarily to improve without much cost the time-table, which on many light railways no longer meets the requirements of the travelling public. It is permissible to hope that, as the result of the increase in the number of the stopping trains and of their greater speed, the total number of passengers will grow. In some cases it will be possible to replace by this type of vehicle, either completely or in part, the actual stopping or mixed trains on the light railways, hauled up to the present by steam locomotives; ultimately it will be possible to utilise these rail motor buses for certain services carrying few passengers on the main lines.

At the end of 1927 three rail motor buses were tested and taken over by the Operating Department, all three made by Czechoslovakian manufacturers (Tatra at Kopřivinice, the Škoda Work at Plzeň, the Czecho-Moravian-Kolben-Daněk Company at Prague). The rail buses are standard gauge and are fitted with explosion motors using dynalcol, the national carburant used in Czechoslovakia. In 1928, 75 rail motor buses were ordered, 5 for narrow gauge lines. These rail motor buses have recently been handed over to the Operating Department (figs. 29 and 30). In addition, the State Railways have started a number of public road omnibus services.

In the near future experiments will be carried out in goods working of tractors driven by internal combustion motors. These tractors are designed to do shunting at stations with light traffic.

In certain cases, investigations are being made into the question of motor goods services both by rail and road. In order to speed up newspaper services, motor vans have been used with very good results (fig. 31).

6. *Brakes.*

Prior to the war, continuous brakes were only fitted on the railways in the Czechoslovakian territory to passenger stock, whilst the goods trains were handbraked. In Austria the Hardy vacuum brake was used; whereas in Hungary the Westinghouse compressed air brake was fitted, so that after the war two types of brakes were in use in Czechoslovakia which resulted in a whole series of difficulties.

After the International settlement of the brake question by the Paris Conference of 1923, the Czechoslovakian State Railways Administration decided to introduce generally the air brake. It standardised first of all the brake for passenger trains by adopting the Westinghouse, at the same time using parts from various manufacturers which practical experience had shewn to be satisfactory. The Westinghouse brake was already in use in Slovakia. In the Western part of Czechoslovakia this brake was and is being introduced in an East to West direction. By 1930, the conversion from the vacuum brake to the air brake throughout the Czechoslovakian State Railways system will be completed.

The question of the continuous brake on goods trains was also the object of a very thorough investigation. For test purposes a matter of 500 wagons have been fitted with Künze-Knorr brake. This brake is in use for coke trains between Moravská Oostrava and Kladno. In addition, the Czechoslovakian lines receive complete trains in transit from Germany braked with the Künze-Knorr brake. A certain number of goods brake vans are fitted with the Westinghouse brake and run provisionally in home service on the fast goods trains between Southern Slovakia and Prague. Recently the Czechoslovakian Railway Administration has received from the Yougo-Slav State Railways a number of wagons fitted with the Božić brake and from the Swiss Federal Railways a number with the Drolshammer brake. After a series of comparative tests, data will be available which will be of use in making a choice of a system of continuous brake for the goods trains in Czechoslovakia. During the next few years the decision as to the system to be adopted will be made, as will be the practical fitting of the continuous brake to the goods wagons in Czechoslovakia.

7. *Other developments in the locomotive running department and the workshops.*

Following another set of ideas, progress in various directions has been realised in the Running Department and in the workshops. For example, a dynamometer car has been ordered and was built by the Ringhoffer firm at Praha and equipped with measuring instruments manufactured by the Amsler Co. of Schaffhouse (Switzerland) and other firms specialising in this class of work. The construction of goods wagons has been improved on scientific lines. New workshops for repairing wagons have been built at Trnava (Slovakia). The tool equipment of the locomotive depots and workshops has been increased and modernised, whilst at the same time every endeavour has been made to obtain a better utilisation of power under different forms, amongst others also the calorific energy. Much progress has been made in the organisation for carrying out the work which in the principal shops has been based on the Taylor method, and has resulted in many economies and a notable acceleration in carrying out the repairs, as well as an improvement in the quality of work.

D — **Operating.**

As a result of the chaos of the early days in the passenger and goods services, the drawing up of time-tables was taken in hand. A considerable number of train services, both in the interior of the State and with foreign countries, were instituted, whilst at the same time many through trains were introduced. Similarly, in the goods service, the speed of the trains was accelerated and through trains introduced. These measures made it possible, to a certain extent, to make up for the excessively elongated geographical configuration of the Czechoslovakian territory.

The Czechoslovakian railway system, as regards its kilometric length is composed almost to one half of light railways. The traffic on these lines was before the war directed by a special organisation at each station, based on the same principle as those of the main lines. The Czechoslovakian Railway Administration is taking steps to reduce the cost of this traffic, whilst maintaining the safety of working. The fundamental idea can be defined as follows : on lines with simple working conditions, the duty of the traffic department employé whilst being the man responsible for the traffic, is quite secondary. His stereotyped work is almost the same every day and it was, in fact, always carried out by the train staff. This state of things gave rise to the idea of confiding the supervision of this work to the man who ac-

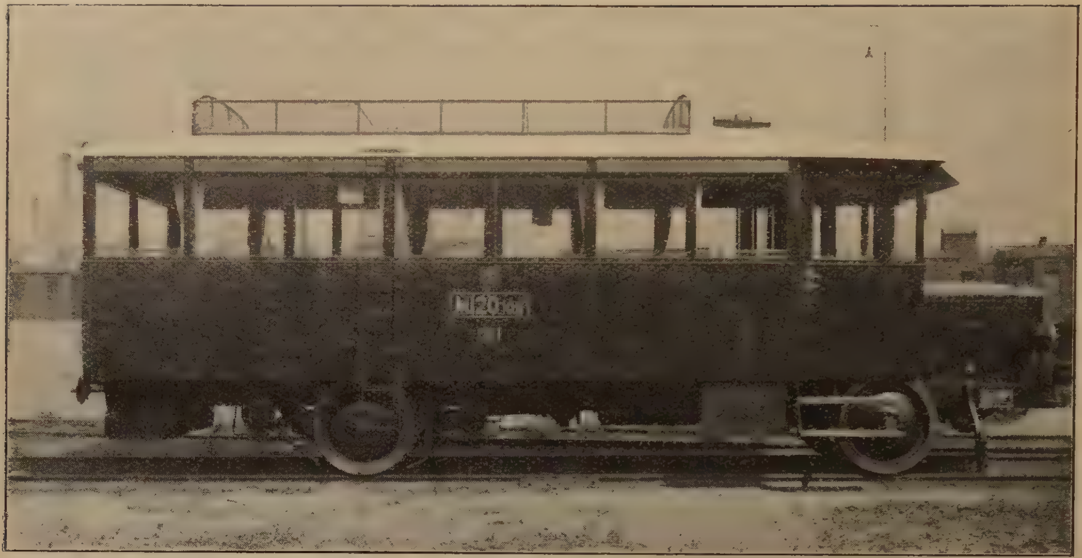

Fig. 29. — Rail motor bus built by the Škoda Company, at Plzeň.

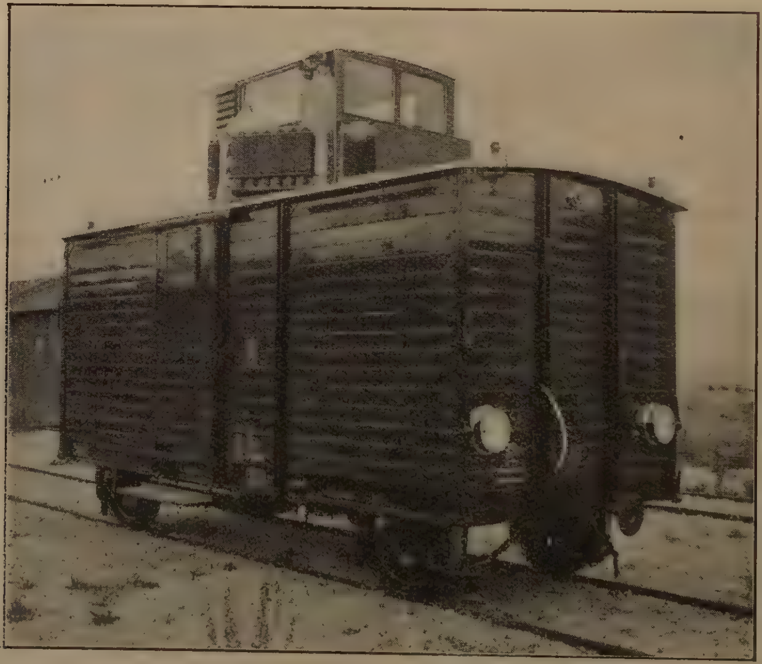

Fig. 31. — Petrol van for carrying newspaper traffic.

tually carried it out, which was the more easily possible as the general and professional railway education of the train staff was improved. Consequently, on the secondary lines, branching off from the main line, an individual employé of the operating department at the junction, or, if preferred, at some other suitable station, was made responsible for the management of the traffic. This employé received by telephone from the guards of the different trains the necessary information relating to the operating, and gave them orders in accordance with which they carried out the working of the trains. The other duties and responsibilities of the operating department's representative are carried out by the guards themselves.

This reform has been introduced already on 3 200 km. (1 988 miles) of local lines and in general has given good results.

On the main lines, the dispatching system is being introduced gradually. In 1924, the dispatching system was in operation on the Praha-Kolin line (63 km. = 39 miles). A new head office position — that of the dispatcher — has been created at the principal stations of certain lines : this dispatcher is connected by telephone continuously with the operating staff at the stations and controls the traffic from the point of view of the needs of the whole of the lines, giving information and advice, and orders as needed.

The dispatching system has given good results : during the following years it was extended and to-day is in use on the Prague-Breclav, Bratislava-Parkán, Ustí-Chomutov lines. It will shortly be introduced on the Zabreh-C. Trebova, Breclav-Bratislava, and Most-Chomutov lines.

For reasons of economy, good results

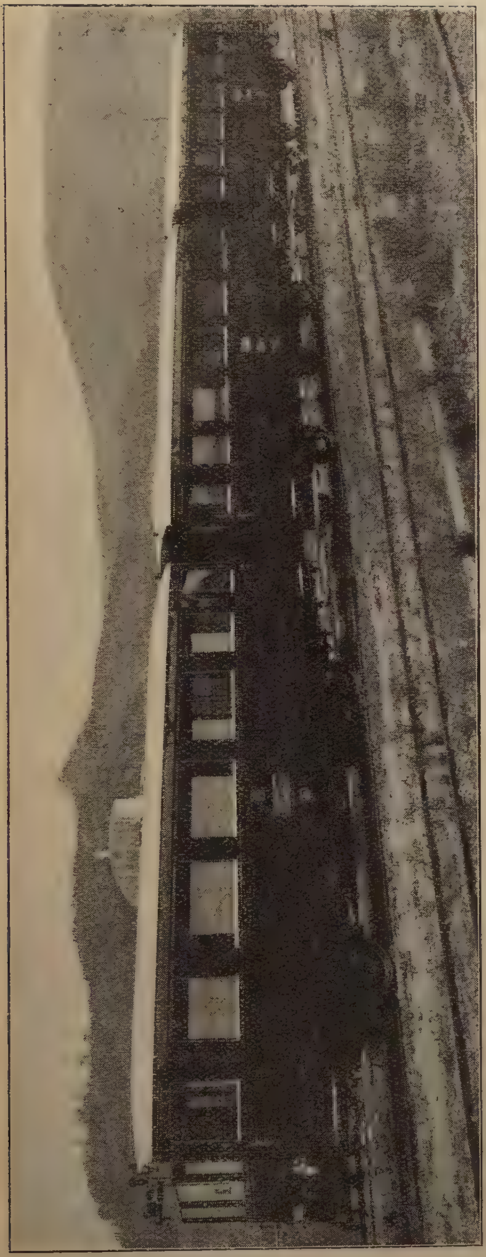

Fig. 30. — Light type rail motor coach with two trailers coupled thereto built by the Tatra Company at Kopřivnice, Moravia.

have also been obtained by interrupting the traffic on days of little traffic, when the number of regular trains is limited to the number strictly needed.

The development of the passenger and goods traffic in Czechoslovakia during the last ten years is brought out by the figures given in table I.

In the rates section of the Czechoslovakian State Railways the old Austro-Hungarian rates have been utilised.

The goods rates of the pre-war Austrian Railways were increased twice during the war, once on the 1 February 1917 by 30 % (even on coal) and on the 1 September 1918 by 70 % (coal only 40 %). In addition, certain increases in detail were made. During the war the passenger rates were raised on the 1 February 1917. The after-war conditions made it necessary for Czechoslovakia to carry out a double majoration of all the goods rates, an increase which was established on a linear basis.

The 1 July 1919 all the rates were raised 100 %. In 1924 these increased rates were again increased 100 %, those for coal 150 %. Since that time the goods rates have not been raised.

On the other hand, the passenger rates have been raised many times.

On the 1 July 1919 the third class rate was raised 50 %, the 2nd, 66.6 %, and the 1st class 100 %. The ratio of the three classes until then 1 : 1.5 : 2.5 was altered to 1 : 1.2/3 : 3.1/3.

The 1 June 1920 at the same time that the passenger rates were increased, uniform regulations were introduced and the rates applied to the new territory of the State. The rates were arranged so that the short distances were charged relatively more than the long. The rates for 250 km. (155 miles) were increased about 48 % so that the price per kilometre was fixed at 16 hellers (25.74 hellers per mile); for a distance of 251 to 350 km. (156 to 217 miles), the rate fell to 12 hellers per kilometre (19 hellers per mile) and for a distance exceeding 351 km. (218 miles), it fell to as little as 6 hellers per kilometre (9.66 hellers per mile), so that the increase in rates for a distance of 800 km. (497 miles) amounted to about 10 %. The difference in the price for the different classes is in the proportion of 1 : 2 : 4. A zone rate was established for short distances by making small zones of 2 to 3 km. (1.24 to 1.86 miles); then for distances above 350 km. (217 miles) zones of a length of 50 km. (31 miles) were arranged. The supplementary rates for the fast trains were arranged in four zones: for the 3rd class for the first zone of 1 to 100 km. (0.62 to 62 miles) a supplement of 8 crowns for express trains; for the following zone up to 500 km. (310 miles) 12 crowns; up to 500 km. (310 miles) 16 crowns, and for over 500 km. (310 miles) 20 crowns. For the 2nd and 1st classes the supplement for fast trains was double and quadruple respectively that of the 3rd.

After the grouping of the private light railways with the State Railways a new tariff of passenger and parcels rates was issued to date from the 1 January 1924.

The price of first class journeys was made three times that of the 3rd; at a later date the 1st class rate was reduced to 2 1/2 times the 3rd. The rates on light railways guaranteed by the State are 50 % higher than those on the State Railways.

In accordance with the governmental order of the 31 July 1925 as from the 1 August 1925 a State tax representing a further increase of 10 % on the passenger fares has been introduced.

As from the 1 August 1926 the fares underwent a final increase of 22 to 25 %.

At the same time the express parcels rate was reduced from four times to twice the luggage rate. As from the 1 April 1927, the cost of 2nd class journeys was reduced so that they became 1 1/2 times that of the 3rd class rate. This reduction restored the proportion of the rates of the different classes of pre-war days, namely 1 : 1 1/2 : 2 1/2.

Special reductions and facilities have been granted to foreigners visiting Czechoslovakia. With this object international tariffs to suit passenger traffic were established. Important fare reductions were granted to visitors to watering places. Such measures contributed to develop the visits of foreigners to Czechoslovakia, and this tendency continues to develop. From information compiled by the headquarters of the Tourist Offices, the number of foreigners visiting Czechoslovakia in 1924 was only 142 633 persons, whereas in 1927 the number had grown to 807 059.

This figure is divided into nearly 38 % from Germany, 20 % from Austria, 10 % from Hungary, 8 % from Poland, 5 % from the United States, nearly 3 % from Rumania and Jugo-Slavia, nearly 2 % from England, France and Russia, 1 % from Italy and the remainder from other countries.

E. — Staff.

After the war the old system of payments and salaries was continued at first, supplemented by allowances for the increased cost of living, adjusted from time to time to the economic conditions at the moment. A new system was introduced in consequence of the new law on rates of pay of the year 1926 by the governmental decree of the 15 July 1927.

The fundamental principle is to pay the staff in accordance with the importance and responsibility of the work done. The employés are divided into groups carrying out duties of the same kind : then in this group, a fixed number of posts corresponding to normal requirements is laid down. To each normal post a definite rate of pay is allotted : the employé appointed to a more important post obtains at the same time the higher rate of pay.

At the present time in the Czechoslovakian State Railways there are 1 276 employés in definite posts on the technical side : 338 employés in the legal department, and 7 729 employés in the operating department.

Taking into account the employés in the medical and the lands services, there are in all 9 402 definite posts. In the group of subordinate employés, there are 17 270 definite posts : in the group of traffic staff there are 79 200 with 37 119 assistants. The total number of employés holding definite posts amounts to 142 991. In addition, temporary staff is taken on as required. This system has been introduced for a provisional period of three years : it will be modified and completed in accordance with the experience acquired.

The number of employés grew considerably immediately after the war, especially as a result of the eight hours' day, and also through the urgent need of the railways in the Eastern part of the Republic. When the conditions were stabilised, no further men could be taken on : during the years 1925-1926 their number was reduced by about 10 %, in consequence of the law for reduction No. 286/1924. The changes in the number of employés of the Czechoslovakian State Railways are shewn in table I.

F. — Financial results.

Under the terms of law No. 404/1922 and of the governmental decree of appli-

TABLE I. — **Growth of the railways operated**

—	1919	1920	1921
Length of lines built in kilometres (in miles)	11 226 (6 976)	11 500 (7 146)	12 254 (7 614)
Length of lines operated in kilometres (in miles)	11 404 (7 086)	11 692 (7 265)	12 419 (7 717)
Number of locomotives and rail motors	3 424	3 560	3 911
Number of carriages	6 346	6 562	7 609
Number of seats in the carriages	287 784	305 980	359 288
Number of wagons	64 845	79 391	98 678
Nominal capacity of the wagons in t. (in English tons)	928 129 (913 470)	1 179 131 (1 160 508)	1 481 633 (1 458 232)
Distance run by the locomotives in locomotive-kilometres (in locomotive-miles)	76 917 781 (47 795 357)	100 368 326 (62 367 113)	118 520 999 (73 646 865)
Locomotive-kilometres per kilometre of line operated (Locomotive-miles per mile of line operated)	8 961	8 716	9 578
Work done by the locomotives in gross tonne-kilometres (English ton-miles)	14 971 129 (9 155 868)	20 260 439 (12 390 642)	23 858 689 (14 591 218)
Normal fuel consumption in t. (in English tons)	3 511 224 (3 455 767)	4 414 790 (4 345 062)	4 447 551 (4 377 306)
Average normal fuel consumption in kgr. per locomotive-km. (in lb. per locomotive-mile)	40.9 (145.1)	41.1 (145.8)	36.2 (128.4)
Ditto for 1 000 gross tonnes-kilometres (for 1 000 gross English ton-miles)	202.8 (731.1)	205.7 (741.5)	181.5 (654.3)
Number of locomotives under repair as a percentage of the total stock	35.0	34.3	32.7
Distance run by wagons in thousands of axle kilometres (in thousands of axle-miles)	1 591 517 (988 941)	2 434 080 (1 512 494)	3 001 704 (1 865 206)
Distance run by wagons in thousands of axle-km. per km. operated (in thousands of axle-miles per mile operated)	185	211	243
Passengers carried	157 827 932	215 106 749	242 187 349
Passengers carried per kilometre (per mile) of line operated	14 449 (23 253)	18 890 (30 400)	19 783 (31 837)
Average passenger journey in kilometres (in miles)	36.72 (22.82)	35.34 (21.96)	40.04 (24 88)
Merchandise carried in t. (in English tons)	43 665 486 (42 975 828)	54 050 310 (53 196 634)	61 550 033 (60 577 906)

y the State during the years 1919 to 1927.

YEAR.						Difference between the years 1919 and 1927 in per cent.
1922	1923	1924	1925	1926	1927	
12 272 (7 626)	13 051 (8 110)	13 037 (8 101)	13 114 (8 149)	13 119 (8 152)	13 154 (8 174)	+ 17.17
12 435 (7 727)	13 260 (8 240)	13 275 (8 249)	13 333 (8 285)	13 343 (8 291)	13 782 (8 564)	+ 17.34
3 969	4 461	4 434	4 311	4 295	4 231	+ 23.57
7 541	8 092	8 222	8 495	8 674	8 717	+ 37.36
343 193	391 336	404 825	418 122	432 553	433 833	+ 50.75
100 170	112 950	113 749	112 581	109 691	108 951	+ 68.02
1 511 912 (1 488 033)	1 666 780 (1 640 455)	1 692 604 (1 665 870)	1 679 455 (1 652 930)	1 658 937 (1 632 736)	1 652 814 (1 626 709)	+ 78.08
125 603 414 (78 047 753)	140 799 757 (87 490 494)	153 831 693 (95 588 310)	155 617 288 (96 697 847)	157 533 883 (97 888 785)	164 247 388 (102 060 439)	+ 63.64
10 114	10 635	11 613	11 692	11 831	12 295	+ 41.06
23 482 797 (14 361 334)	25 554 689 (15 628 437)	30 131 458 (18 427 444)	31 133 677 (19 040 370)	32 189 669 (19 686 181)	34 299 743 (20 976 636)	+ 69.29
4 177 053 (4 111 108)	4 211 912 (4 145 389)	4 619 786 (4 546 820)	4 397 732 (4 328 274)	4 238 674 (4 171 728)	4 411 786 (4 342 106)	+ 25.65
32.8 (116.4)	29.3 (103.9)	29.4 (104.3)	27.6 (97.9)	26.5 (94.0)	26.5 (94.0)	— 35.21
177.7 (640.6)	164.4 (592.6)	152.9 (551.2)	140.9 (507.9)	131.7 (474.8)	128.7 (463.9)	— 36.54
30.9	27.6	24.6	22.9	22.1	20.7	— 14.3
2 982 387 (1 853 203)	3 261 939 (2 027 159)	3 801 812 (2 362 379)	3 897 128 (2 421 607)	4 047 507 (2 515 050)	4 286 719 (2 663 692)	+ 170.11
240	246	287	293	304	321	+ 52.13
247 345 138	268 791 095	296 877 103	302 773 800	302 608 384	292 344 731	+ 85.23
20 119 (32 378)	20 512 (33 010)	22 646 (36 445)	22 995 (37 006)	22 902 (36 856)	21 885 (35 220)	+ 51.46
30.53 (18.97)	29.92 (18.59)	29.73 (18.47)	30.31 (18.83)	30.18 (18.75)	28.56 (17.75)	— 22.22
57 600 230 (56 690 486)	75 969 079 (74 769 215)	88 693 997 (87 293 155)	88 400 246 (87 004 044)	87 860 257 (86 472 583)	93 947 056 (92 463 247)	+ 115.15

TABLE I. — Growth of the railways operated

—	1919	1920	1921
Merchandise carried per kilometre operated in t. (per mile operated in English tons)	3 951 (6 258)	4 694 (7 435)	4 976 (7 881)
Average distance hauled per tonne carried, in kilometres (per English ton carried, in miles) (1)	94.46 (57.77)	93.93 (57.44)	96.06 (58.75)
Total number of staff	147 633	165 041	176 697
Number of staff:			
a) par kilometre (per mile) of line operated	14.58 (23.46)	14.33 (23.06)	14.28 (22.98)
b) per 100 000 locomotive-kilometres (per 100 000 locomotive-miles)	. .	164.44 (264.63)	149.08 (239.92)
c) per 100 000 axle-kilometres (per 100 000 axle-miles)	...	7.22 (11.61)	5.89 (9.48)

(1) Without including temporary staff. If these be included the maximum number of employés for th

TABLE II. — Financial results of the Czechoslovakian State Railwa

—	1919	1920	1921
Operating receipts	1 211 236 970	3 273 064 450	5 062 099 16
Expenditure of ordinary working and other outlays	1 283 255 490	3 266 915 070	5 609 021 84
Cost of renewals	255 074 361	980 190 337	1 083 843 21
Total operating costs	1 538 329 851	4 247 105 407	6 692 865 05
Deficit or excess from the operating	— 327 092 881	— 974 040 957	— 1 630 765 89
Operating co-efficient	127.00	129.76	132.21
Interest on railway capital	13 972 390	9 265 430	7 261 59
Net deficit or profit	— 341 065 271	— 983 306 387	— 1 638 027 48
Investments	74 946 020	283 887 064	340 652 42
Difference to be covered either by the Treasury or by borrowing	— 416 011 291	— 1 267 193 451	— 1 978 679 91
Receipts from the transport taxes (taxes on passenger tickets and luggage and tax on the traffic)	182 932 497	484 898 912	694 107 97

(1) The figures for

by the State during the years 1919 to 1927. (*Continued.*)

YEAR.						Difference between the years 1919 and 1927 in per cent.
1922	1923	1924	1925	1926	1927	
4 645 (7 357)	5 741 (9 093)	6 705 (10 620)	6 644 (10 523)	6 600 (10 454)	7 033 (11 140)	+ 78.01
112.44 (68.76)	101.66 (12.17)	110.43 (67.53)	111.56 (68.23)	116.33 (71.14)	118.98 (72.76)	+ 25.96
171 019	169 907	162 393	146 418	143 513	134 187	— 9.11
13.77 (22.16)	12.83 (20.65)	12.26 (19.73)	11.00 (17.70)	10.78 (17.35)	10.05 (16.17)	— 31.67
136.16 (219.12)	120.67 (194.19)	105.57 (169.90)	93.76 (150.89)	91.10 (146.61)	81.70 (131.48)	— 50.31
5.73 (9.22)	5.21 (8.38)	4.27 (6.87)	3.76 (6.05)	3.55 (5.71)	3.13 (5.04)	— 56.65

year 1926 would be 164 234 or 13.23 per kilometre (19.84 per mile) of length operated.

and the receipts from the transport taxes during the years 1919 to 1928.

1922	1923	1924	1925	1926	1927	1928 (1)
4 402 176 350	4 590 887 210	4 408 423 760	4 332 728 150	4 352 386 380	4 553 075 670	4 575 511 320
5 001 669 870	4 668 592 900	4 010 204 140	3 951 146 040	3 853 547 635	3 880 818 250	3 933 736 480
618 259 227	376 004 211	420 406 461	250 982 542	201 831 754	137 869 166	138 959 280
5 619 929 097	5 044 597 111	4 430 610 601	4 202 128 582	4 055 379 389	4 018 687 416	4 072 695 760
— 1 217 752 747	— 453 709 901	— 22 186 841	+ 130 599 568	+ 297 006 991	+ 534 388 254	+ 502 815 560
127.66	109.88	100.50	96.98	93.17	88.26	89.01
6 622 790	111 719 780	256 166 680	304 227 490	377 080 530	376 947 230	341 624 290
— 1 224 375 537	— 565 429 681	— 278 353 521	— 173 627 922	+ 80 073 539	+ 157 441 024	+ 161 191 270
302 421 168	319 381 974	307 859 605	253 632 826	292 154 827	299 130 024	301 191 270
— 1 526 796 705	— 884 811 655	— 586 213 126	— 427 260 748	— 372 228 366	— 141 689 000	— 140 000 000
610 747 054	599 719 681	689 548 950	670 451 084	670 908 879	715 537 894	710 000 000

ear 1928 are provisional.

cation No. 206/1924, the Czechoslovakian State Railways form one of the State Undertakings. For this reason they have their own separate budget, only the balance of which appears in the State budget. The legal requirements quoted above imposed two duties upon the Czechoslovakian State Railways : they should carry out their mission of political economy in the best possible way as regards the public interest; they should be managed in accordance with the principles followed by any good business to cover from the receipts the costs of operation, and to obtain as far as possible a net profit for the benefit of the State. The accountancy of the Czechoslovakian State Railways, originally kept in the simple way used on the old Austrian State Railways, has since 1925 followed the double entry system giving more precise figures more quickly.

Table II sums up the financial results of the Czechoslovakian State Railways during the last ten years.

The unfavourable economic situation after the war, the precarious position of the railway system, as well as various other difficulties mentioned at the beginning af this article, are reflected in the unfavourable financial results for the period 1919 to 1924. During these years the operating costs largely exceeded the receipts. It was only after 1925 that the co-efficient of working fell below 100 % : during the last years it has varied between 88 and 89 %.

This improvement is due as much to reduction of expenses resulting from methods of economy and re-organisation, as to the increase in receipts which shew, especially in 1927 and 1928, a steady tendency to improve.

The indebtedness of the railways has grown appreciably since the period when the Czechoslovakian State Railways Administration took over, on the one hand the liabilities of the Austrian and Hungarian Railways, and on the other the liabilities of the private companies which were bought out and finally when the Administration had to increase its indebtedness by certain capital borrowings.

The financial position — although greatly improved — does not permit of the railway system being as quickly remade as required by the new conditions, such as the growth of traffic. The capital expenditure made these last years in order to complete and improve the system has not been excessive, as a matter of fact, when the state of the system is considered.

This expenditure is met in part at the present time out of the net operating earnings, in part by subsidy from the State Ministry of Finances, which for this object remits to the Railway Administration part of the taxes on the traffic.

To sum up, the financial situation of the Czechoslovakian Railways has definitely improved during recent years. As in the case of most European railways, the operating results are sometimes still far off the pre-war figures, which is moreover also caused by the rapid increase in other means of transport, especially by road motor vehicles.

Furthermore, the state of the Czechoslavakian system, even in the future, will demand heavy expenditure on rebuilding and equipment. These circumstances will also oblige the Railway Administration of the Czechoslovakian State to continue, in financial matters, to progress with prudence on the lines that up to the present have given satisfactory results.

[625 .1 (44 + .460)]

The transpyrenean railways, (1)

By Marcel GARAU,

CHIEF ENGINEER, BRIDGES AND ROADS SERVICE,
CHIEF ENGINEER FOR NEW WORKS OF THE MIDI RAILWAY COMPANY.

Figs. 1 to 6, pp. 374 to 383.

I. — History.

Prior to the opening on the 18 July 1928 of the new line between Bedous and Jaca, France and Spain were only connected by railways at the ends of the Pyrenean range : by the line along the Atlantic coast through the frontier stations of Irun and Hendaye, and by the line along the Mediterranean coast through the frontier stations of Cerbère and Port-Bou.

The first of these lines was opened in 1864 and the second in 1878.

Even before these lines were opened to traffic, the need for other lines of communication between France and Spain was felt, that is to say of lines crossing the Pyrenean range.

No less than a dozen schemes have been prepared since 1865.

Amongst the lines considered, was that from Prades to Puigcerda, under the Col de la Perche.

This latter proposal was set aside from the first as not solving the transpyrenean problem, and as requiring with the standard gauge and gradients of 1 in 30 a tunnel 13 km. (8.1 miles) long, under the Col de la Perche. As a matter of fact, it has turned out to be the first transpyrenean railway as a result of the construction of the line from Villefranche to Bourg-Madame, opened in 1911, and which has just been extended as far as the future international station of La-Tour-de-Carol on the Toulouse-Barcelona transpyrenean railway, via Ax and Ripoll. This line which serves the French Cerdagne district, crosses the Col de la Perche in the open at 1 584 m. (5 197 feet) above sea level, near Mont-Louis, the line between the French and Spanish water sheds and ends quite near the frontier right at the Spanish town of Puigcerda.

Until 1881, the investigations were continued : on the one hand France, holding to the two schemes, Mauléon-Roncal to the west, and Saint-Girons to Lérida by the Col de Salau to the east : on the other, Spain to the Vallée d'Aspe project.

The first step towards the realisation of the transpyrenean lines, was accomplished by Spain. Without any preliminary agreement with France, the Spanish Government took in hand the construction of the transpyrenean railway by the Vallée d'Aspe, and H. M. Alphonso XII, officially started the undertaking in October 1882. The Spanish Government desired in fact to reward Aragon for its fidelity during the carlist war. Spain ran the risk of course, owing to there being no agreement with France,

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(1) Translated from the French.

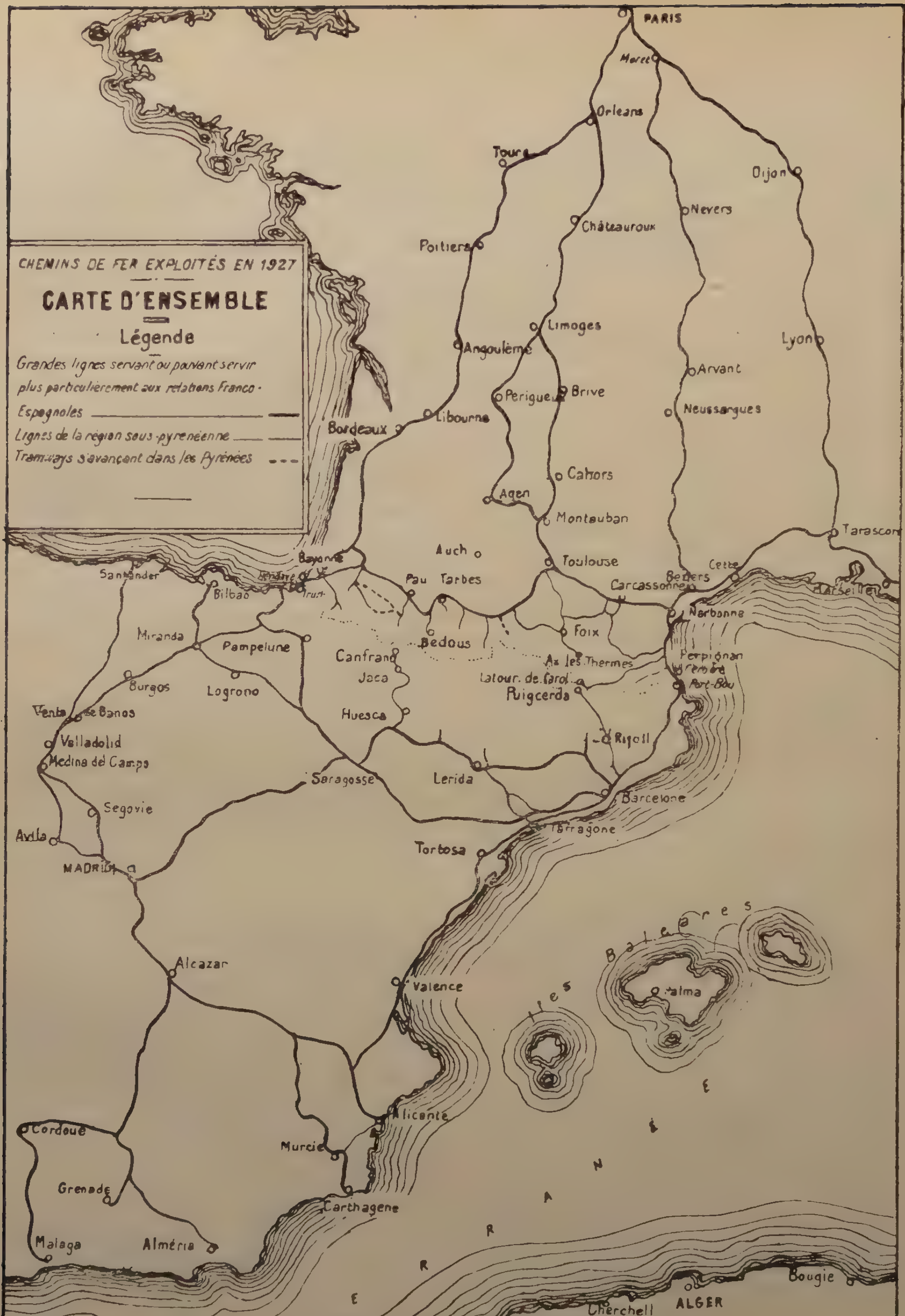


Fig. 1. — *(For explanations see opposite page).*

Translation of legend of fig. 1 (map on opposite page) :

Railways in operation in 1927.

GENERAL RAILWAY MAP.

Explanation :

Main lines in use or which could be used especially for Franco-Spanish traffic	━━━━━━━━
Lines in the Pyrenean Country	——— ———
Light railways in the Pyrenees	— — — — — — —

of building a railway which would end in a cul-de-sac.

As for the Toulouse to Lérida line, Spain stated it could only agree to it, provided it ran by the Val d'Aran, whereas France wanted it to run by the Vallée du Salat, and Saint-Girons.

On the 13 February 1885, a diplomatic agreement was concluded on the subject of the two lines selected, that of the Vallée d'Aspe, under the Col du Somport, that of the Vallée du Salat, via Saint-Girons, and the Port de Salau. These two lines were to be built in ten years. These agreements were never ratified, however.

In 1903, a quite unexpected event occurred, which brought the solution nearer realisation.

On the 7 March 1903 by a letter from Mr. Cambon, the French Ambassador at Madrid, to the Spanish Minister for foreign affairs, the French Government took the initiative in proposing to the Spanish Government the « provisional substitution » of the line from Ax-les-Thermes to Ripoll, being a « line in anticipation », prior to the construction of that from Saint-Girons to Lérida.

In this way, a third and new transpyrenean railway made its appearance.

On the 18 August 1904, an agreement was signed by the Spanish Ambassador at Paris, and Mr. Delcassé then French Minister for foreign affairs, fixing a period of 10 years from the ratification of the agreement for the construction of the line from Ax to Ripoll. As for the Saint-Girons to Lérida line, the period of 10 years was to run from the date the Spanish Government announced the completion of the line from Lérida to Sort. An additional protocol fixed at 10 years the time for completing this last line.

On the 27 January 1907, the two Governments exchanged the ratifications of the agreement and of the additional protocol.

On the 2 August 1907, a law declared the construction of the line to be of public utility and conceded definitely, to the Midi Company, the line from Ax-les-Thermes to the frontier, and that from Bedous to the frontier and conceded, subject to it being declared of public utility, the line from Oust to the frontier.

On the 18 July 1928, the Transpyrenean Railway from Bedoux to Jaca was opened in state by H. M. Alphonso XIII, and the President of the French Republic.

In order to complete this brief historical review of the transpyrenean railway question, a word should be said about the recent investigation into locations of lines with a view to improving communication between Paris and Madrid. A very important point dominates the question, as will be seen by a glance at the map : the straight line from Paris to Madrid, does not cross the Pyrenees, but passes by Hendaye. If the French

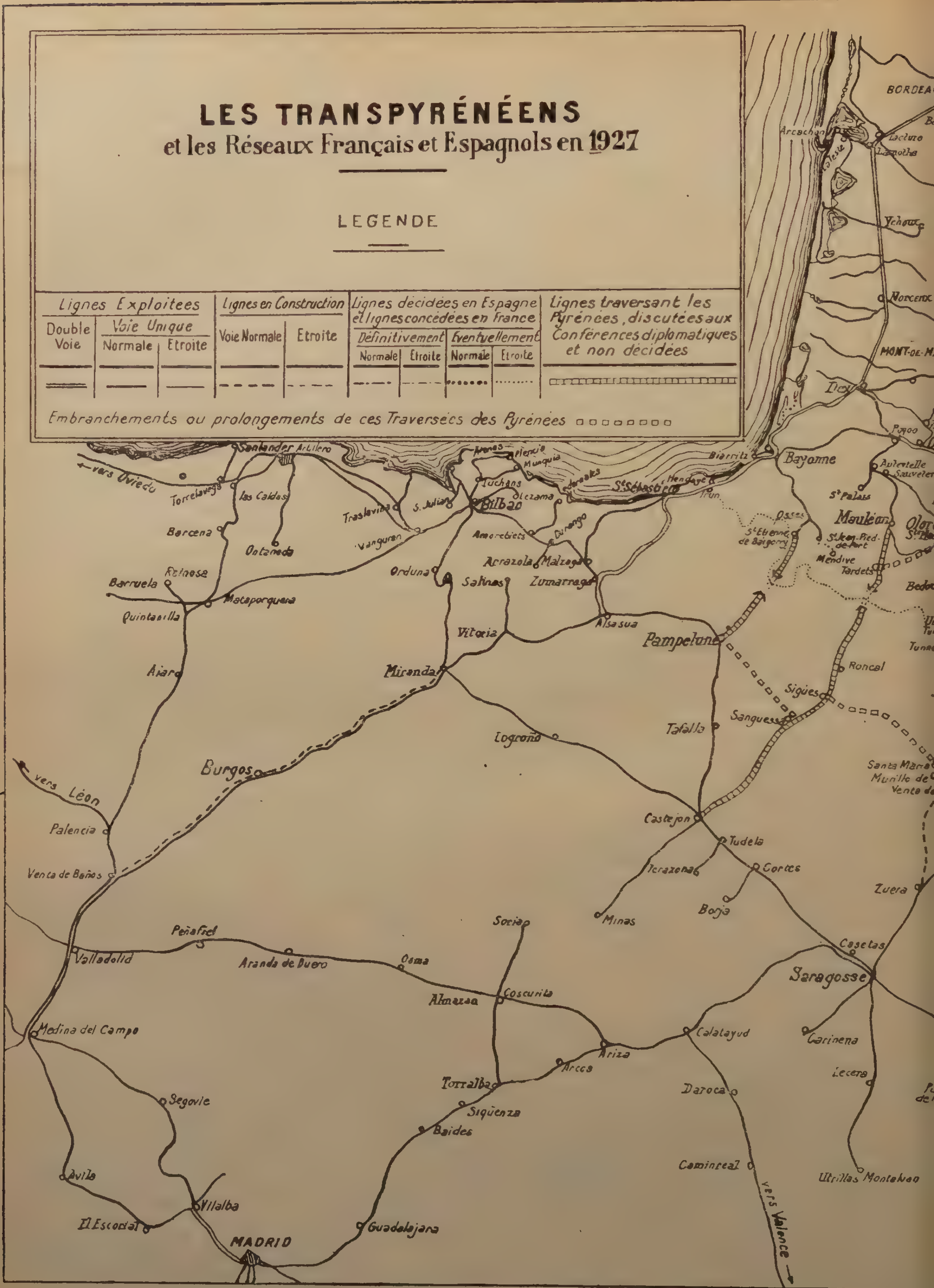
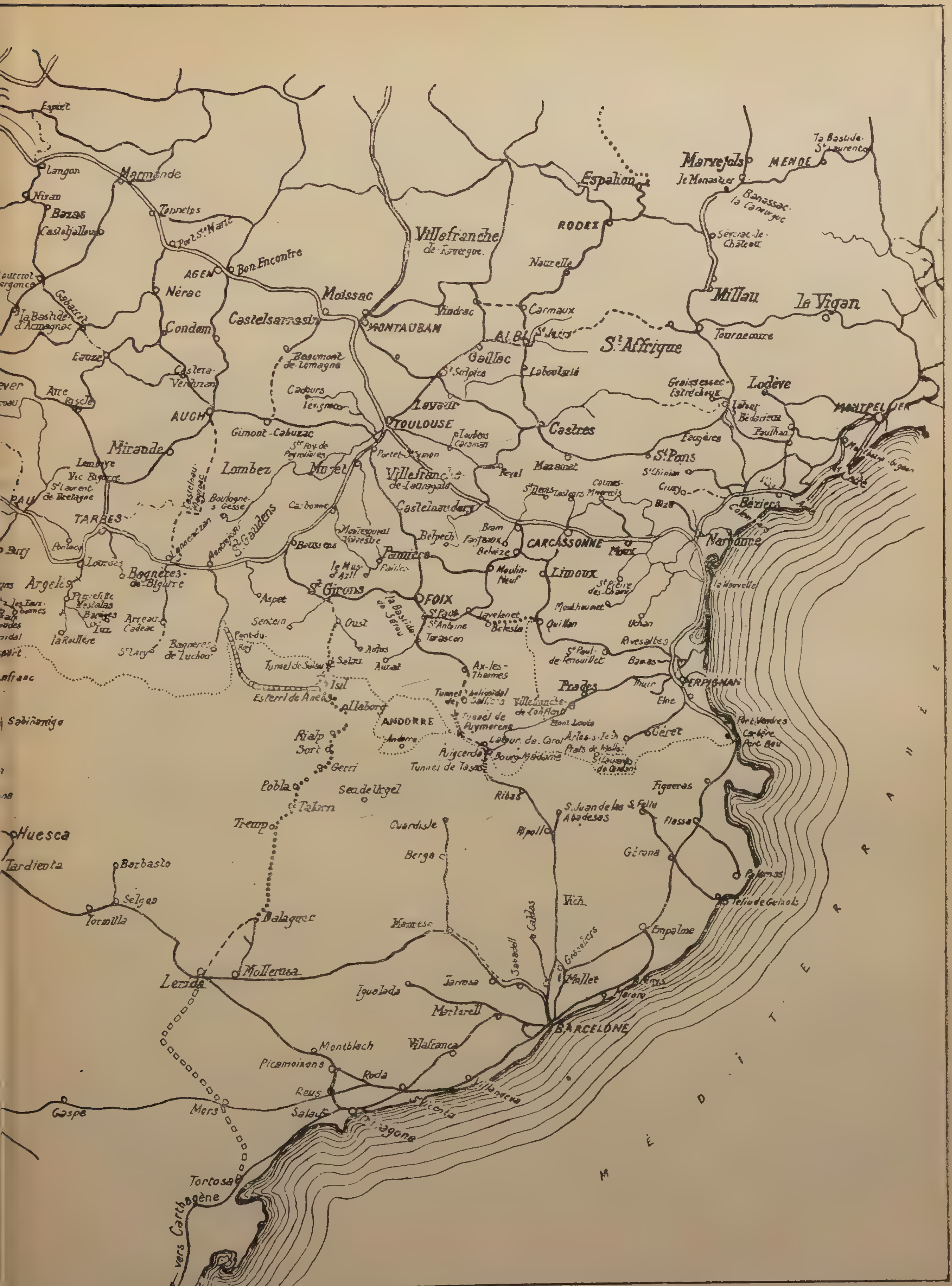

LES TRANSPYRÉNÉENS
et les Réseaux Français et Espagnols en 1927
LEGENDE
Lignes Exploitees
Double Voie
Voie Unique
Normale
Etroite
Lignes en Construction
Voie Normale
Etroite
Lignes décidées en Espagne et lignes concédées en France
Définitivement
Éventuellement
Normale
Etroite
Normale
Etroite
Lignes traversant les Pyrénées, discutées aux Conférences diplomatiques et non décidées
Embranchements ou prolongements de ces Traversées des Pyrénées
BORDEAU
Arcachon
Lacture
Lamothe
Ychoux
Morcenx
MONT-DE-M
Dax
Puyoo
Biarritz
Bayonne
Autevielle
Sauveterre
St Palais
Mauléon
Olor
St Jean-Pied-de-Port
Mendive
Tardets
Bedo
Ossès
St Etienne de Baigorry
Hendaye
Irun
St Sébastien
Santander
Artilero
vers Oviedo
Torrelavega
Las Caldas
Barcena
Ontaneda
Traslaviña
S. Julian
Bilbao
Plencia
Munguia
Lezama
Durango
Amorebieta
Arrazola
Malzaga
Zumarraga
Vanguren
Orduna
Salinas
Reinosa
Barruela
Mataporquera
Quintanilla
Aïar
Vitoria
Alsasua
Pampelune
Miranda
Roncal
Sigües
Sanguesa
Tafalla
Logroño
Burgos
vers Léon
Palencia
Venta de Baños
Castejon
Tudela
Cortes
Borja
Minas
Santa Maria
Murillo de
Venta de
Zuera
Casetas
Saragosse
Cariñena
Lecera
Utrillas Montalban
Peñafiel
Valladolid
Aranda de Duero
Osma
Soria
Coscurita
Almazan
Medina del Campo
Ariza
Calatayud
Arcos
Torralba
Siguenza
Baides
Daroca
Caminreal
Segovie
Avila
Villalba
El Escorial
Guadalajara
MADRID
vers Valence

Fig. 2. — (For exp



n, see following page).

Translation of legend of figure 2 (map on two preceding pages) :

TRANSPYRENEAN RAILWAYS
and the FRENCH and SPANISH SYSTEMS in 1927.

Explanation :

Lignes exploitées = Lines in use. — Lignes en construction = Lines under construction. — Double voie = Double track. — Voie unique = Single track. — Normale = Standard gauge. — Etroite = Narrow gauge. — Lignes décidées en Espagne et lignes concédées en France = Lines sanctioned in Spain, and lines conceded in France. — Lignes traversant les Pyrénées, discutées aux conférences diplomatiques et non décidées = Lines crossing the Pyrenees, discussed at diplomatic conferences but not sanctioned. — Embranchements ..... Pyrénées = Branches or extensions of these lines crossing the Pyrenees.

section Paris-Hendaye is only a little off the straight line, this is not the case with the Spanish section, Irun-Madrid.

The improvement of the service between Paris and Madrid is therefore a problem which can be said to be exclusively Spanish.

We may add that a Royal Decree of the 17 July 1928 decided to alter the gauge of the line from Puigcerda to Barcelona to the standard European gauge, so that stock can run through to Barcelona via Toulouse and Ax.

II. — Brief description of the transpyrenean railways.

a) *Transpyrenean railway from Bedous to Jaca under the Col du Somport.*

This transpyrenean railway, which was opened in July 1928, gives communication between Pau and Saragossa by the Aspe Valley and that of Aragon.

It is an extension of the present Pau to Bedous line; the Pau-Oloron section was opened in 1882 and the Oloron- Bedous section in 1914. The last section from Bedous to the frontier was opened in July 1928.

The Bedous to the frontier section is 28 km. (17.4 miles) long. It climbs up the Gave d'Aspe from the Bedous station at 400 m. (1 312 feet) above sea level to the Somport tunnel, at 1 211 m. (3 973 feet) and then falls to the international station of Canfranc at 1 194 m. (3 917 feet) in Spanish territory in the Aragon Valley.

The gradients are as severe as 35 mm. per metre (1 in 28 1/2) between Bedous and Etsaut. Beyond this latter station the line is largely on a gradient of 43 mm. per metre (1 in 23 1/2).

The minimum radius of the curves is 200 m. (10 chains).

The Gave d'Aspe is crossed by two steel bridges of 37.5 m. (123 feet) and 50 m. (164 feet) span and by three viaducts : one of five arches of 8 m. (26 ft. 3 in.) and a steel span of 60 m. (196 ft. 10 in.); the second of six arches of 8 m. (26 ft. 3 in.) span and a steel span of 60 m. (196 ft. 10 in.) and the third of one arch of 41.5 m. (136 ft. 2 in.) and two arches of 12 m. (39 ft. 4 in.) and 8 m. (26 ft. 3 in.).

There are fourteen tunnels between Bedous and the frontier. The longest are : the Portalet of 940 m. (1 028 yards) the spiral tunnel of 1 750 m. (1 914 yards) and the summit tunnel, that of the Somport of a total length of 7 875 m. (8 612 yards) of which 3 160 m. are in France, and 4 715 m. in Spain.

b) *Transpyrenean railway from Ax-les-Thermes to Ripoll through the Col de Puymorens.*

This transpyrenean railway provides the direct through line between Toulouse and Barcelona, by giving communication between the Ariège basin and that of the

Carol, a tributary of the Sègre, itself a tributary of the Ebro. It is a continuation of the Toulouse line to Ax-les-Thermes of which the Toulouse-Foix section was opened in 1861, the Foix-Tarascon section in 1877, and the Tarascon-Ax section in 1888. The last section from Ax to the frontier will be opened in 1929.

The line from Ax-les-Thermes to the frontier is 42 km. (26 miles) long. It leaves Ax at 700 m. (2 297 feet) above sea level and quickly rises through the Haute-Ariège Valley up to l'Hospitalet where it runs into the Puymorens tunnel at a level of 1 580 m. (5 184 feet). Owing to the line the frontier follows, the passage through the Pyrenean Chain under the Col de Puymorens is entirely in French territory; from this point, the line descends along the Carol Valley to the French international station of La-Tour-Carol at 1 230 m. (4 035 feet) level.

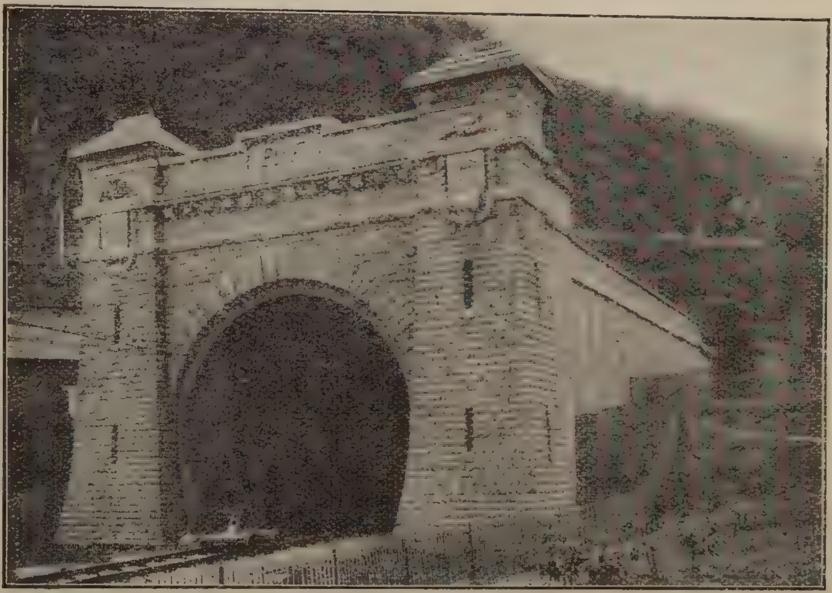


Fig. 3. — Bedous to Jaca line. — French end of the Somport tunnel.

The gradients of the line are for the greater part of the distance, 40 mm. per metre (1 in 25). The minimum radius of the curves is 200 m. (10 chains).

There is a large number of bridges and viaducts, all masonry except for a steel bridge of 18 m. (59 feet) span over the Nabre and some short span steel bridges crossing the Oriège, the Nabre, the Ariège and the Carol rivers. There are eleven tunnels on the line all on the Ariège side, the longest being the spiral tunnel, 1 750 m. (1 914 yards) the Barthe-Espesse, 1 220 m. (1 334 yards) and lastly the Puymorens 5 355 m. (5 856 yards) on a gradient of 34 mm. per metre (1 in 30) on the Ariège side, and on a down gradient of 30 mm. (1 in 33 1/3) on the Carol side.

At La-Tour-de-Carol, the French inter-

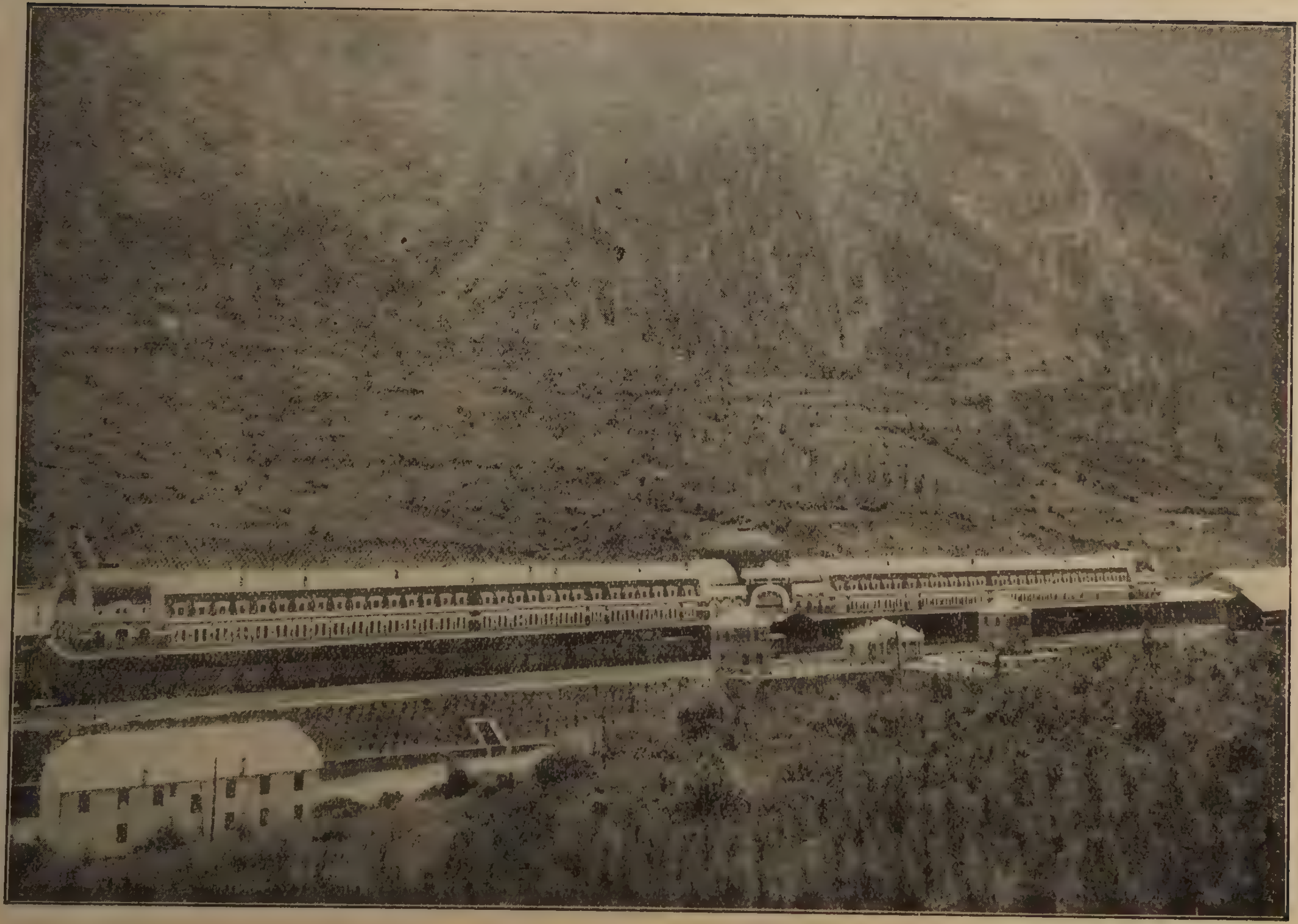


Fig. 4. — Bedous to Jaca line. — International station at Canfranc.

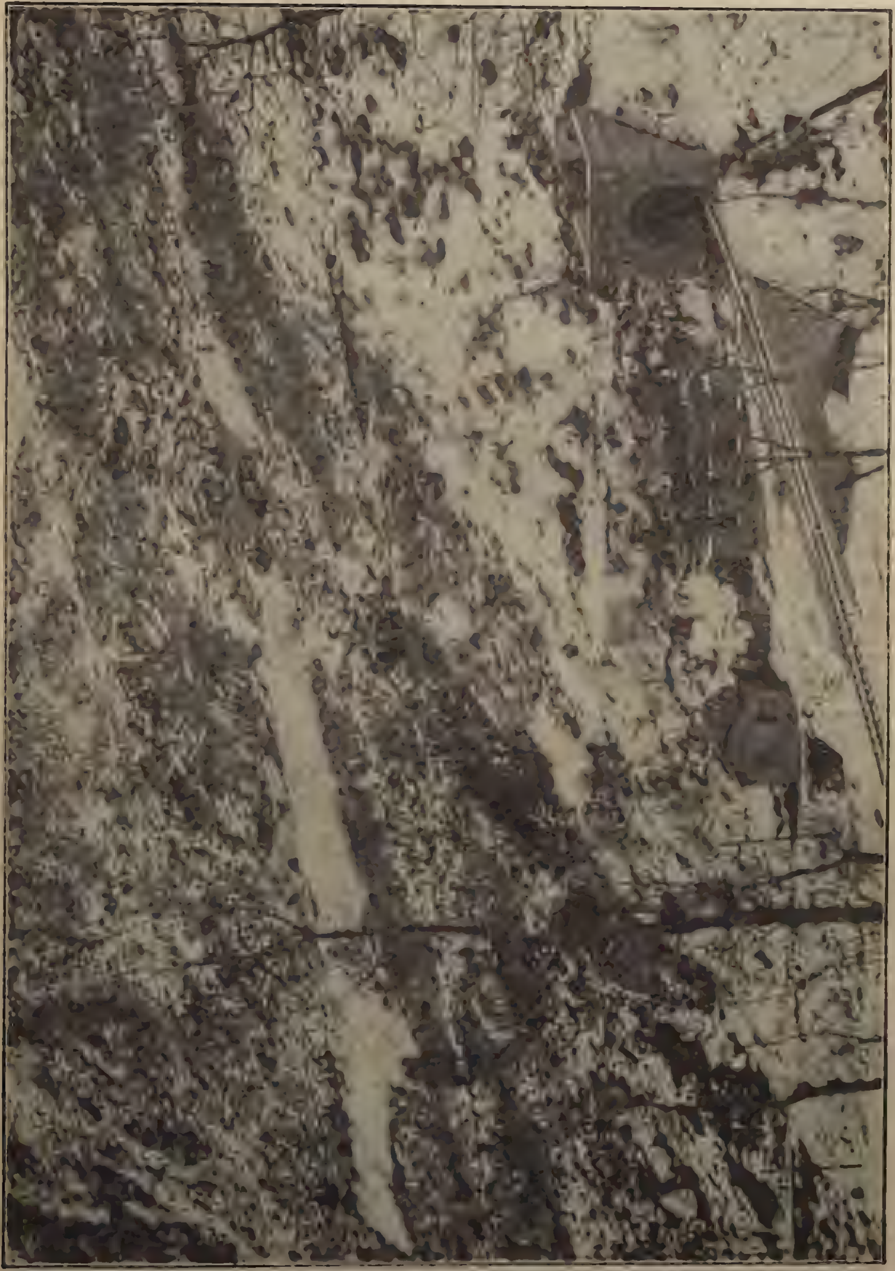


Fig. 5. — Ax-les-Thermes to Ripoll line. — Spiral tunnel of Saillens.

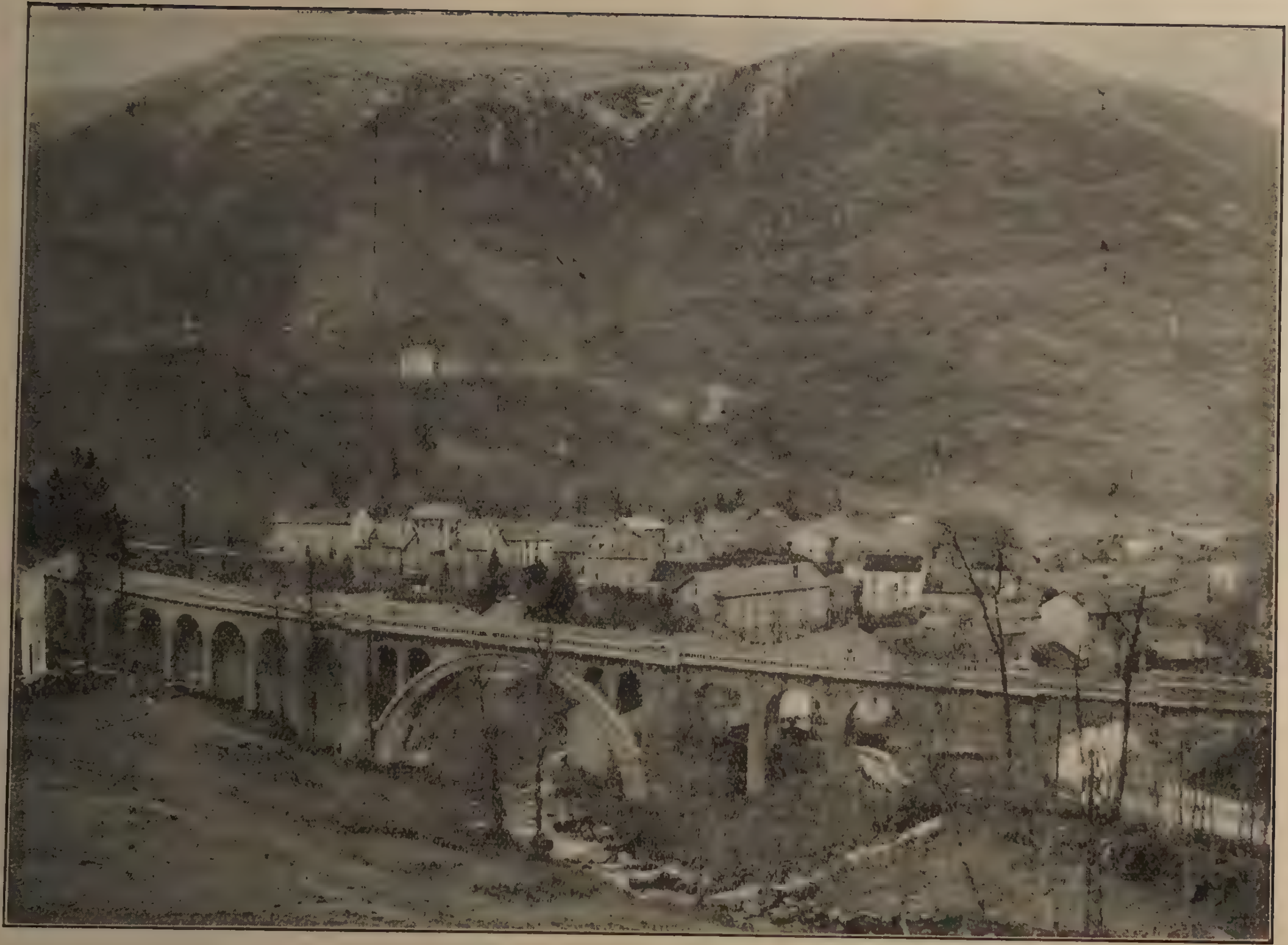


Fig. 6. — Ax-les-Thermes to Ripoll line. — La Lauze viaduct and view of Ax-les-Thermes.

national station is the junction with the narrow gauge electric railway from Villefranche-Vernet-les-Bains to La-Tour-de-Carol.

After passing the international station at La-Tour-de-Carol, the transpyrenean railway crosses the frontier and arrives at the Spanish international station, Puigcerda.

After leaving this station, the line crosses the Sègre, climbs up the valley, passes under the Col de Tosas at 1 494 m. (4 902 feet) level, runs down the Ter Valley which it follows and then rises again to 600 m. (1 969 feet) and then descends to Barcelona.

At the present time the Spanish Government has not found anyone willing to operate the line and is operating it with a reduced service by steam between La-Tour-de-Carol and Ripoll. The Royal Decree of the 17 July 1928, has, however, laid it down that the operation of the line shall be leased to the Northern Company which holds the concession of the Barcelona-Ripoll line.

c) *Transpyrenean railway from Saint-Girons to Lérida by the Port de Salau.*

The section from Saint-Girons to Oust, 17 km. (10.6 miles) long is in course of construction. There are still 23 km. (14.3 miles) between Oust to the frontier, to build. On the Spanish side the line is being operated between Lérida and Barcelona a length of 25 km. (15.5 miles) and is under construction between Balaguer and Tremp, a length of 50 km. (31 miles). There remains to be built in Spain 40 km. (24.9 miles) from Tremp to Sort, plus 43 km. (26.7 miles) from Sort to the frontier or 83 km. (51.6 miles) in all.

III. — **Expected results from the transpyrenean railways.**

The opening of the two lines via Bedous and via Ax will very materially shorten distances. Paris will be brought nearer : to Madrid, by 27 km. on 1 460 km. (16.8 miles on 907 miles); to Cartagena by 172 km. on 1 951 km. (107 miles on 1 212 miles); to Saragossa by 65 km. on 1 158 km. (40.4 miles on 720 miles) and to Barcelona by 107 km. on 1 080 km. (66.4 miles on 671 miles).

The distances from Bordeaux will be reduced by 27 km. on 876 km. (16.8 miles on 544 miles) to Madrid; by 172 km. on 1 366 km. (107 miles on 849 miles) to Cartagena; by 65 km. on 573 km. (40.4 miles on 356 miles) to Saragossa; and by 107 km. on 682 km. (66.4 miles on 424 miles) to Barcelona.

The reduction in distance from Pau will be: 140 km. on 783 km. (87 miles on 487 miles) to Madrid; 306 km. on 1 294 km. (190 miles on 804 miles) to Cartagena; 179 km. on 481 km. (111 miles on 299 miles) to Saragossa and by 408 km. on 848 km. (254 miles on 527 miles) to Barcelona. Toulouse will be brought nearer to Madrid by 140 km. on 983 km. (87 miles on 611 miles); Cartagena by 107 km. on 1 059 km. (66 miles on 658 miles); Saragossa by 178 km. on 680 km. (111 miles on 423 miles); Barcelona by 107 km. on 426 km. (66 miles on 265 miles).

Without leaving France the distance by railway between Toulouse and the Cerdagne via Ax will only be 2/3rds of the present distance via Perpignan. The saving in time will, of course, not be in proportion to the saving in length. The speeds on the transpyrenean lines with their curves of 200 m. (10 chains) radius and gradients of 40 and 43 mm. per metre (1 in 25 and 23 1/3) and the fact that they are single tracked, can not be as high as on the coast lines even though they are operated electrically.

These lines will be of the greatest interest from the tourist traffic point of view.

From the financial point of view, the reduction in the distances will certainly develop the present traffic and exchange between the two countries. Moreover the exchange by land between France and Spain is only 1/3 of the total trade by land and sea. It is therefore reasonable to think that making available other means of communication by land, both more numerous and more convenient, can not fail to restore to the land route a part of the present enormous advantage held by the sea route.

It should not be lost to view that the industry and commerce of Spain is developing more and more, from a pre-war beginning, followed up and accelerated during and after the war. Such a rise cannot but result in a steadily increasing growth in the traffic in transit by the Franco-Spanish railways.

An undoubtedly important factor in the improvement of the rail communications will be the alteration to the standard European gauge of the line to Barcelona by Ax and Ripoll in accordance with the Royal Decree of the 17 July 1928 which ordered the alteration of the gauge between Barcelona and Puigcerda. In accordance therewith, passengers will arrive at the underground station to be built under the Plaza di Catalonia and the free port of Barcelona will be served by standard gauge lines.

[625 .142.4]

Reinforced concrete sleepers,

Vagneux system.

Figs. 1 to 21, pp. 386 to 406.

(*La Technique des Travaux.*)

The problem of the reinforced concrete sleeper, has been considered as practically speaking insoluble for a long time.

At the International Railway Congress (Rome 1922) at which it was discussed, Mr. Grierson, the special reporter (section I — Ways and Works — Question IV) was, in fact, obliged to declare (¹) :

« Many railway companies, in almost « all countries have tested reinforced « concrete sleepers, but no one could say « the experiments had been satisfactory. « The reporters criticise the considerable weight of these sleepers, their « cost, the difficulty of handling them, « their small resistance to shock, and « finally, the difficulty of finding a satisfactory rail fastening. »

However, the late Mr. Cartlidge, special reporter for America (²) whilst agreeing that the trials had not been satisfactory, whether from a technical, or a commercial point of view, expressed the opinion that it was possible to make sleepers of sufficient strength, and that they ought to give a better track than that obtained with wooden sleepers.

Mr. Desprets, Engineer, Belgian State Railways, published in the *Bulletin of the International Railway Congress Association* for July 1922, an article on the recent types of reinforced concrete sleeper, which ended in the following conclusion :

« It would appear that from the technical point of view, the reinforced « concrete sleeper, when well designed, « can give as good results as the ordinary wood sleeper.

« It is probable, furthermore, that the « type of sleeper likely to have the « greatest future, will be developed from « the Vagneux sleeper with steel tie bar.

« In addition to the effective tamping « possible with this design of sleeper, « this sleeper is not liable to breakage « under the reaction of the ballast as « were older rectangular shaped sleepers. The steel cross tie being able to « undergo considerable deformation « without breaking, would provide complete safety in this respect. »

Messrs. Cartlidge and Desprets have appreciated the subject correctly. The reinforced concrete sleeper, as imagined and developed by Mr. Vagneux, Chief Engineer of the Paris, Lyons and Mediterranean Railway Company, emerged successfully, and that several years ago, from the experimental period, and in France, and in several other countries,

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(¹) See *Bulletin of the Railway Congress*, April 1922, p. 643.

(²) See *Bulletin of the Railway Congress*, July 1921, p. 761.

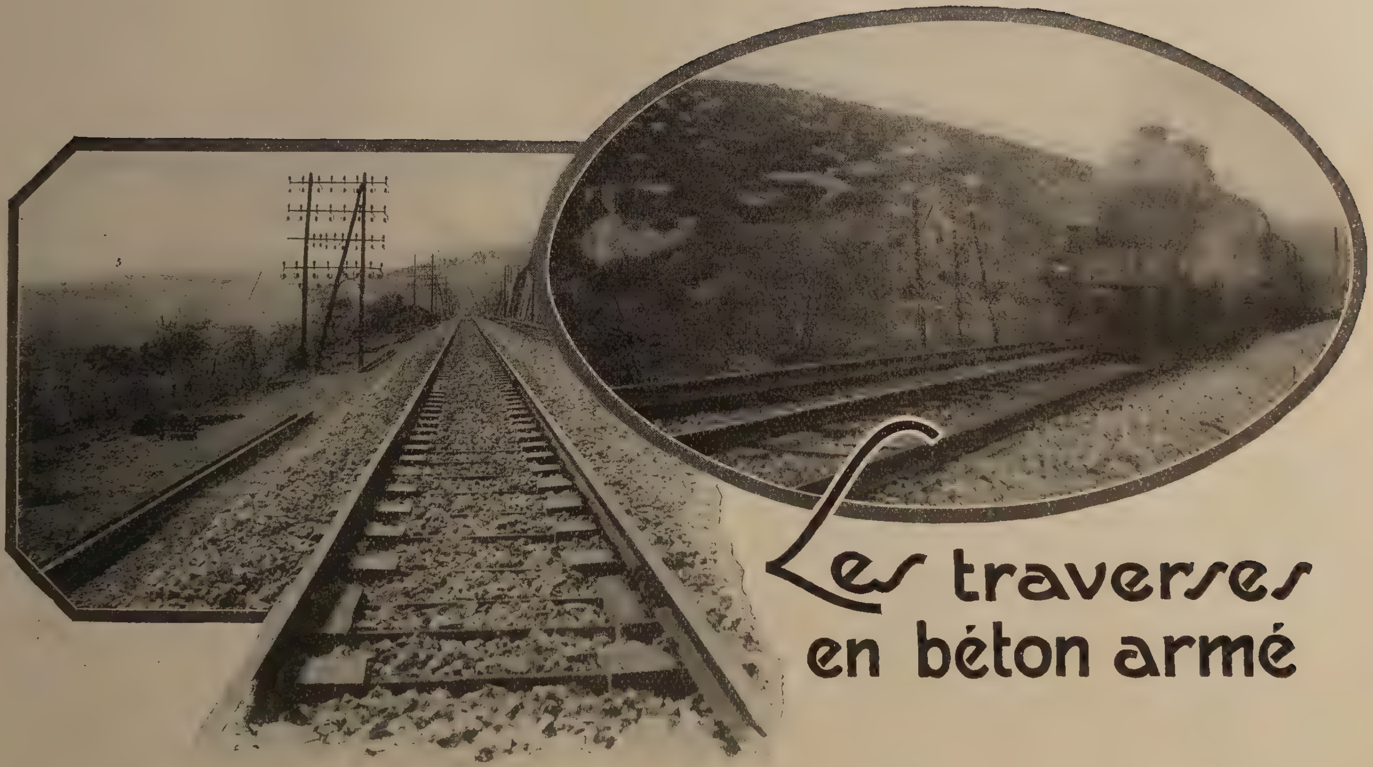


Fig. 1. — Paris Lyons and Mediterranean Railway. Paris to Marseilles line, Plombières-lez-Dijon section. *Mountain* type locomotive hauling an express train over track laid on Vagneux sleepers.

. *Explanation of French terms* : Les traverses en béton armé = Reinforced concrete sleepers.

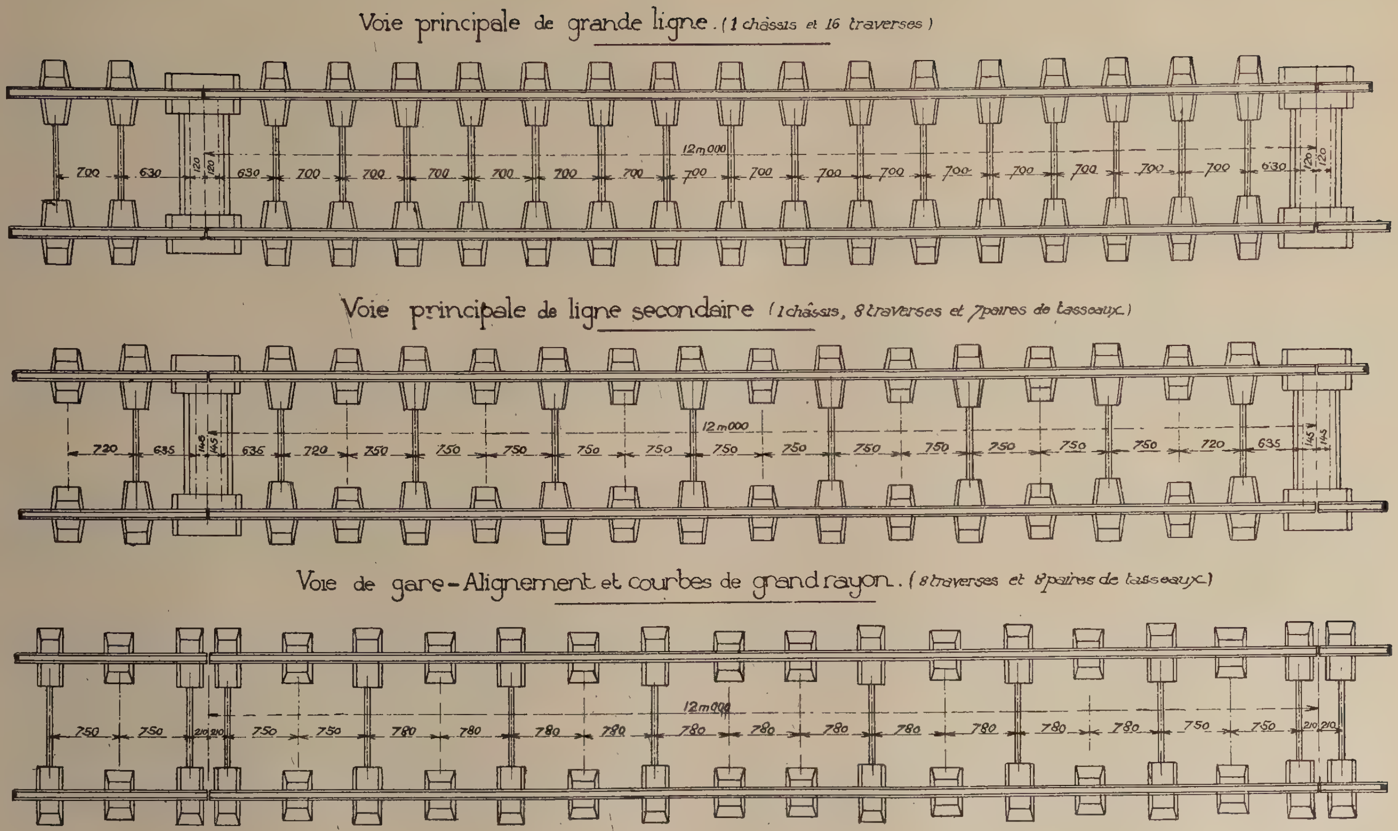

Voie principale de grande ligne. (1 châssis et 16 traverses)
12m000
700
630
120
120
630
700
630
120
120
Voie principale de ligne secondaire (1 châssis, 8 traverses et 7 paires de tasseaux)
12m000
720
635
145
145
635
720
750
635
145
145
Voie de gare - Alignement et courbes de grand rayon. (8 traverses et 8 paires de tasseaux)
12m000
750
210
210
780
750
210
210

Fig. 2. — Examples of sleeper layouts.

Explanation of French terms : Voie principale de grande ligne, etc.... = Main line on first class lines (1 joint frame and 16 sleepers). — Voie principale de ligne secondaire, etc..., Main line on secondary lines (1 joint frame, 8 sleepers, and seven pairs of pot sleepers). — Voie de gare. - Alignement et courbes, etc... = Station lines - tangents and large radius curves (8 sleepers, and 8 pairs of pot sleepers).

has been widely used on many railway systems, both standard and narrow gauge.

As this reinforced concrete sleeper has been able to stand up in lines carrying the fastest traffic (Paris to Lyons, Paris to Nîmes, Paris to Strasbourg, Paris to Brussels, and Paris to Calais lines) and as it is the most widely used at the present time, we have felt it fitting to devote a special article to it.

Standard gauge.

We will begin with the standard gauge line sleeper, which consists for important main lines of the ordinary sleepers and joint frames and in the case of secondary main lines and station sidings, of sleepers and joint frames and block or pot sleepers.

Sleepers. — The Vagneux sleeper has the original feature of being a composite sleeper (steel and reinforced concrete) of a semi-rigid type.

The central part is a rolled steel girder, simply embedded in two end blocks which are of reinforced concrete of about 70 cm. (27 1/2 in.) in length by 25 to 35 cm. (9 7/8 to 13 3/4 inches) in width.

This sleeper, therefore, cannot be packed along its middle part.

The tie is of sufficiently rigid section to maintain the gauge of the line, and the correct inclination of the rails, and at the same time, of sufficient elasticity to absorb without danger to the concrete, the torsion, or bending stresses caused by unequal tamping under the two blocks or by the settling of one block in relation to the other.

In order to appreciate how decisive a factor this elastic cross tieing can be, it should be sufficient to remark that sleepers entirely made of reinforced concrete, have not stood up in standard lines under average loading, except as the result of the precaution found necessary, of digging out and maintaining a trench in the ballast under the middle of the sleeper.

It is principally because this precaution had not been taken, that the test on a very wide scale made in Italy between 1910 and 1912, with more than 300 000 sleepers, was such a failure. But the fact of having a trench along the centre, with its many drawbacks and the constant care needed in maintenance, becomes useless as regards the reduction of the bending moment when, for any reason whatever (settling of the subsoil, partial loosening of the ballast) one of the blocks of the sleeper settles appreciably in relation to the other. This bending moment — so far as one can determine graphically, or by calculation — may then exceed all reasonable values.

This is the reason why certain inventors have thought the depth of the central part of reinforced concrete sleepers ought to be increased.

In this order of ideas, may be cited the Borini sleeper, in which the central portion is fish-bellied and sunk in the ballast : Mr. Borini. however, has been careful to declare (*Bulletin of the Railway Congress*, January 1927) :

« We do not pretend to have solved, « with this improvement in the shape of « the rigid sleeper, the difficult problem « in question; we have solely the convic- « tion of having made progress towards « it. »

It was therefore necessary, for complete success, to abandon the rigid type of sleeper, and to introduce, as Mr. Vagneux did, a sufficiently elastic member into the design of the sleeper.

The reader will have realised, that the composite sleeper, having the same bending moment where embedded in the concrete (that is to say under the rails), is very much lighter than a sleeper entirely made of reinforced concrete. The Vagneux sleeper, with, it is true, the end blocks having been given the forms approaching as closely as possible, as the drawings show, those of solids of equal strength, only weighs, in fact, 150 to 175 kgr. (330 to 387 lb.) according to the pattern : 150 kgr. (330 lb.) for chaired track, and 175 kgr. (387 lb.) for Vignole rails (large pattern) whereas the rectangular sleepers at present in use on the various French systems (with central trench in the ballast) weigh generally about 270 kgr. (595 lb.).

These latter sleepers, therefore, use more material (sand, gravel, and cement), and even more steel than the Vagneux sleeper, even when the cross tie bar is taken into account. They are therefore necessarily more expensive. In addition, they are more difficult to handle, and require special equipment, whereas the Vagneux sleeper is carried very easily by means of rail tongs, by which the cross tie bar is gripped.

The encastrement of the cross tie bar in the blocks of the Vagneux sleeper, is obtained, as we said, by the simple adhesion of the steel and of the concrete. The laboratory of the « Ecole des Ponts et Chaussées de France », having carried out, the 22 April 1926, a test by pulling out the tie bar, recorded a resistance of 12 380 kgr. (27 292 lb.). This is evidently greater than that needed.

The only objection that can be raised against the use of the cross tie bar, is the liability to rust. The same question of course can be raised in the case of the metal sleeper. As a rule, the bar can be sufficiently well protected by a coat of black metallic varnish. It is also possible, and use has confirmed the utility of the method, to coat the sides of the tie bar with concrete, so that it is only necessary to paint the top and bottom of the flanges, to get almost perfect protection. It is obviously possible to use tie bars of the so called rustless steel, following the American method.

Joint frames

The Vagneux sleeper equipment includes the use, under the joints, of a special bearing or *joint frame*, the substitution of which for two sleepers, has as its principal objective, the improvement of the riding of the stock, and the reinforcement of the weak points of the track, to an appreciable extent.

The joint frame consists of two reinforced concrete blocks, connected together by two I girder bars, but whereas the two sleeper blocks have their larger dimension at right angles to the track, the ends of the frame or longitudinal sleepers have their larger dimension (72 to 80 cm. = 28 3/8 to 31 1/2 inches) parallel to the rails, their width being 42 cm. (16 1/2 inches).

The surface area of these blocks is therefore nearly double that of an ordinary sleeper block.

The joints overhang to a small extent beyond two packing pieces of hard wood, or between two chairs, carried on ties, in carefully selected positions, with regard to the joint.

The packing pieces are sufficiently close together for the frame not to tilt, when a wheel passes from a trailing on to a leading rail, when passing over the joint.

The utility of this special support will be appreciated, when it is noted that whereas the rail in the solid bar works as a continuous girder, which distributes the vertical loads, and the transverse stresses acting on the track, over a certain number of sleepers, each of which only supports a fraction of these loads and transverse stresses, it is not at all the case near the joints. The fish plated joint ought in principle, to make good the break in continuity of the rails, but as it can only play this part very imperfectly, because it has to be capable of being undone readily, the joint sleepers are driven into the ballast more than the others, under the weight of the wheels, so that there results frequently a permanent deformation of the track, which appears at each joint as a settlement of the ballast in the form of a channel.

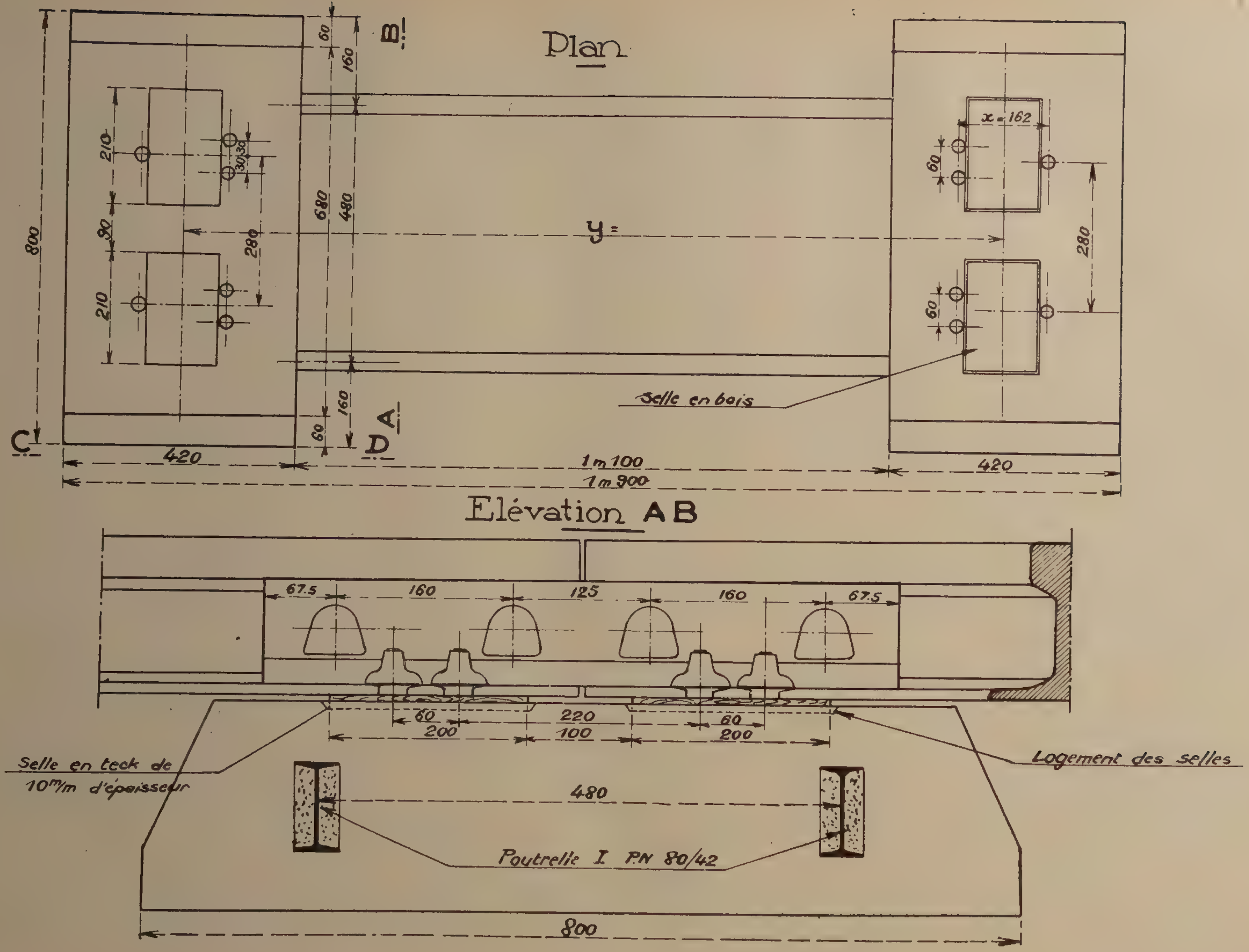


Fig. 5. — Joint frame. Large pattern 1928 (12 fastenings).

Explanation of French terms : Logement des selles = Packing groove. — Poutrelle I, P. N. 80/42 = I girder, P. N. 80/42 (3 5/32×1 21/32 inch.). Selle en bois = Wooden packing. — Selle en teck, etc... = Teak packing 10 mm. (3,8 inch) thick.

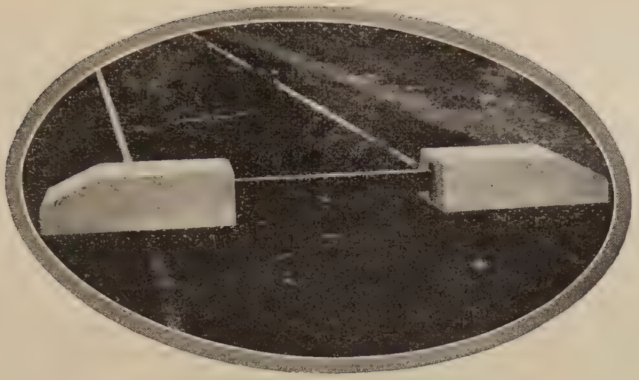


Fig. 3. — Vagneux reinforced concrete sleeper.

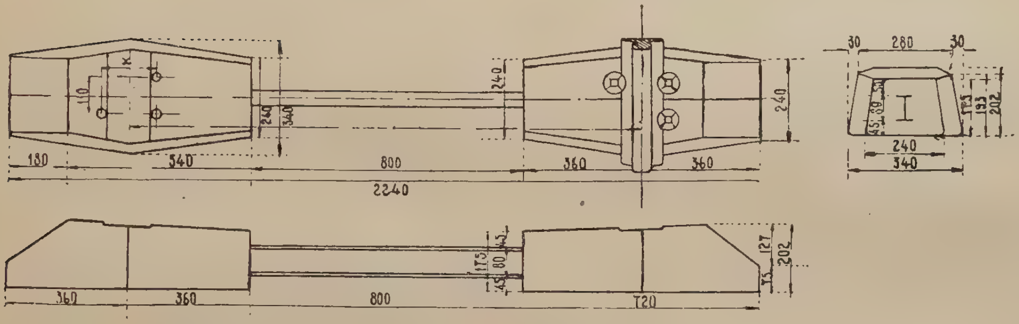


Fig. 4. — Ordinary sleeper, large pattern.

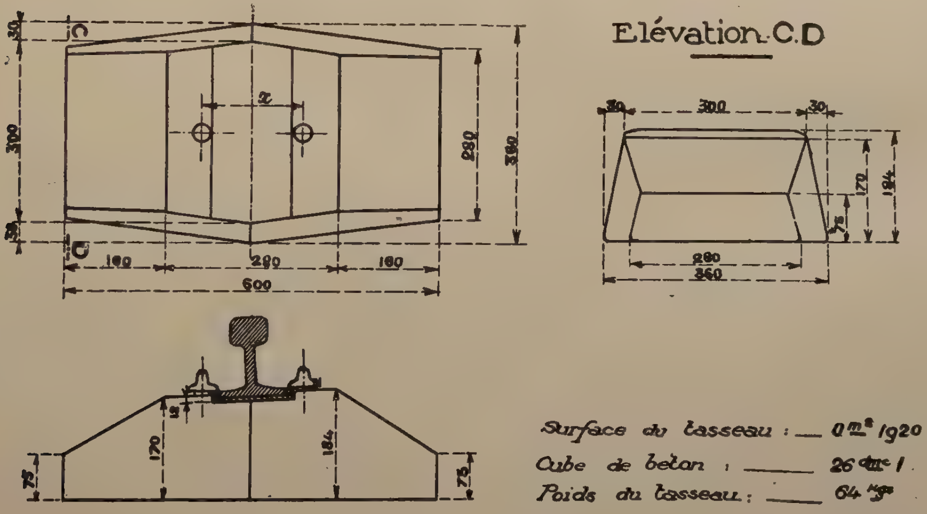

Elévation C.D
C
D
30
300
30
x
280
380
160
280
160
600
30
300
30
170
184
75
280
360
15
170
184
75
75
Surface du tasseau : — 0 m² 1920
Cube de beton : — 26 dm³ 1
Poids du tasseau : — 64 kgs

Fig. 6. — Pot sleepers.

Explanation of French terms : Elévation C. D. = Elevation C. D. — Surface du tasseau : 0 m² 1920 = Area of the block 0.1920 m² (2.07 square feet). — Cube de béton : 26 dm³ = Volume of concrete : 26 cubic decimetres (0.918 cubic foot). — Poids du tasseau : 64 kgr. = Weight of the block : 64 kgr. (141 lb.).

The joint sleepers, moreover, are driven in turn into the ballast.

The difference between their vertical movements is the principal cause of the wear of the fish plates, and of the movement of the joint as a whole : it produces the shocks felt and heard, when running over the joints.

The tread of the wheel of a vehicle on a track laid on sleepers all identical, therefore does not roll over a continuous line reproducing the theoretical linear profile of the track.

It is a reproduction of the profile of the track, when at rest, with its possible permanent deformations to which must be added, the vertical depression of each point of the rail under the moving wheel : this running surface is therefore irregular, downwards with a sudden rise at each joint.

Mr. Vagneux invented the joint frames in order to suppress these irregularities of the running surface, irregularities which increase the tractive effort required, and which prejudice the conservation in a good state of repair of both the rolling stock and the permanent way.

Practical experience, has confirmed these theoretical conclusions. The riding is extremely smooth on lines laid with Vagneux joint frames : passengers have commented upon the fact. The graphs taken with the Hallade recorder, have demonstrated the correctness of these observations.

It is obvious that it should be possible to use in conjunction with joint frames securing to the same sleepers the ends of the rails, thinner fish plates than the usual pattern, especially if they are fitted with devices such as the Brandt plate to ensure the bolts remaining tighter, or with shorter fish plates, with two bolts only, such as the Coullié chevron fish plate.

Up to the present, the standard fish plates of the railways have been used.

Several designs of joint frames specially adapted to the standard French track (46 kgr. = 94.2 lb. per yard rails) are reproduced.

This track is laid by certain railways, with angle fish plates, forming an anti-creep device, and by others with flat fish plates.

There are some joints in tracks laid with long rails, at which joint frames ought not be fitted : such as when the joints of the two sets of rails are out of square too much (over 4 cm. = 1 9/16 inches). Such joints are found on curves as a result of having to use short rails on the inner side.

When the amount the ends of the rails are out of square is too great, the fastenings do not fall into place properly as compared with fish plated rails, using angle fish plates; with ordinary fish plates the joint frames are too much in front of the fish plate bolts, and the coach screw spanner can only be got into position with difficulty, if at all. At such unusual points, two ordinary sleepers are used.

The general use of the joint frame under the joints, moreover, is not absolutely essential. When particular reasons lead to the use of joint sleepers, it is advisable to give them such a shape that one can if possible, place them side by side, as is actually done with the wood sleepers.

Blocks. — The cross stays between the end blocks of the sleepers, have as object, the maintenance of the gauge and of the inclination of the rails, in spite of the transverse stresses, to which they are subjected. These stresses vary considerably with the speed of the trains, and especially with the layout of the line : they become of especial importance on sharp curves, on which the vehicles inscribe themselves with difficulty.

As the cross tying of all the sleepers is adequate on curves of small radius, run over at fairly high speeds, it is more than is needed on straight sections run over at average speeds, or on curves of large radius, at reduced speed.

It would be possible, consequently, with a view to economy, to replace a certain number of sleepers by pairs of blocks, or pots, without connecting them together, and this still more readily, if the joints were laid on joint frames at the same time.

The saving effected by the judicious use of pot sleepers, is considerable, from the fact that a sleeper costs almost double the price of a pair of pot sleepers.

A certain number of station lines, or private sidings, have been laid with sleepers and pot sleepers, in the proportion of one pair of pot sleepers per sleeper. In the main lines, it is advisable to limit the use of pot sleepers, to straight lengths, over which the speed does not exceed 60 to 70 km. (37 to 43 miles) per hour, and to curves taken at reduced speed of a radius exceeding 300 m. (15 chains) using a pair of pot sleepers for every two sleepers.

Rail fastenings.

The fastening forms a vital point of every reinforced concrete sleeper. It is, of course, quite easy to devise an arrangement having sufficient mechanical strength, but it is much more difficult to insure they will not slacken off, when in service in the track. *The following condition is however essential :* the reinforced concrete sleeper must become, as it were, a very part of the rail.

If the rail can « hammer » on the sleepers, the bearing surface will be subjected to shocks, the effect of which can only be diminished by interposing, between the rail and the sleeper, a fairly strong plate, which will, however, wear quite quickly and its subsequent frequent renewal, will form a costly charge. The loosening of the fastenings, will also result necessarily in the sleeper hammering on the ballast, through which the under side of the sleeper would soon become damaged.

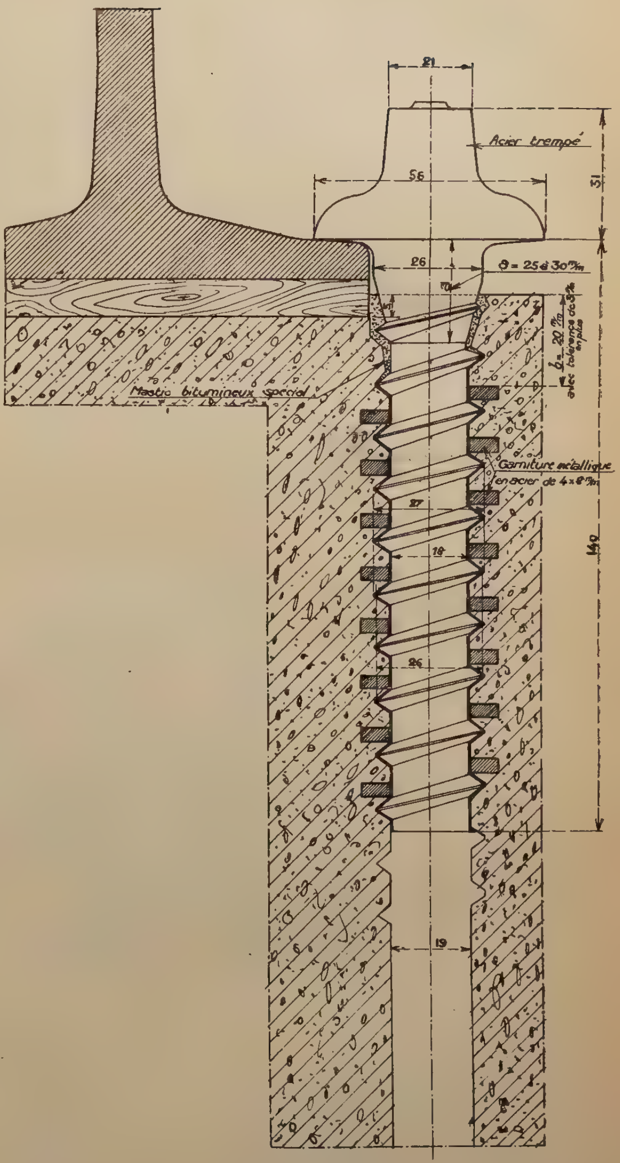

21
Acier trempé
56
31
26
θ = 25 à 30 m/m
b = 20 m/m avec tolérance de 5 m/m en plus
Mastic bitumineux spécial
Garniture métallique en acier de 4 × 8 m/m
27
18
140
26
19

Fig. 7. — Detail of fastening using a special coach screw.

Explanation of French terms : Acier trempé = Tempered steel. — Garniture métallique en acier de 4 × 2 mm. = Steel fitting, 4 × 2 mm. (5/32 × 5/64 inch). — Mastic bitumineux spécial = Special bituminous mastic.

In the Vagneux sleepers, the problem of the fastening has been solved, in two different ways, depending upon whether one is dealing with an ordinary line, or a line through the rails of which very weak electric currents have to circulate, in which case, it is necessary to use sleepers, the blocks of which can be insulated electrically, one from the other.

The second case, is that of lines with the automatic block, or section having « track circuits », preceeding certain electric signals.

Ordinary fastenings. — The fastening which can be removed is anchored in the concrete, by means of a coach screw, which screws into a screwed hole cast in the concrete casting by using a threaded plug, the thread of which has been carefully calibrated. This plug, prior to molding, is fitted into a helicoidal half round steel wire thread on the Thiollier system, which remains embedded in the concrete when the plug is withdrawn, so as to form part of the screwed hole, level with the cylindrical wall.

The screwed hole, forms therefore a composite concrete and steel nut, the steel only acting to strengthen the concrete and distribute through the mass of it beyond the threads in the concrete the stresses due to pulling out, etc. It has been found by means of the « Collet extrahometre », that the resistance to pulling out of a fastening of this type, is always greater than 5 tons, and often even than 8, or 10.

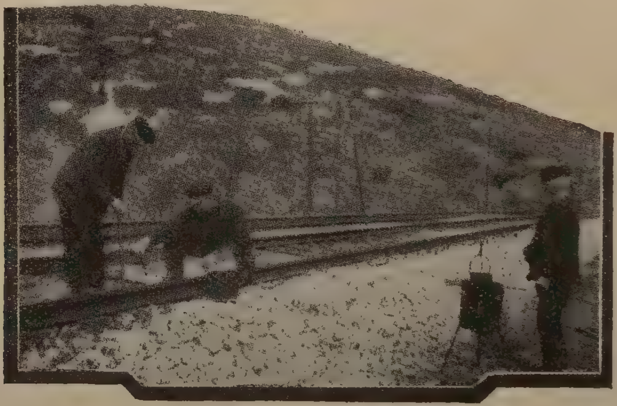
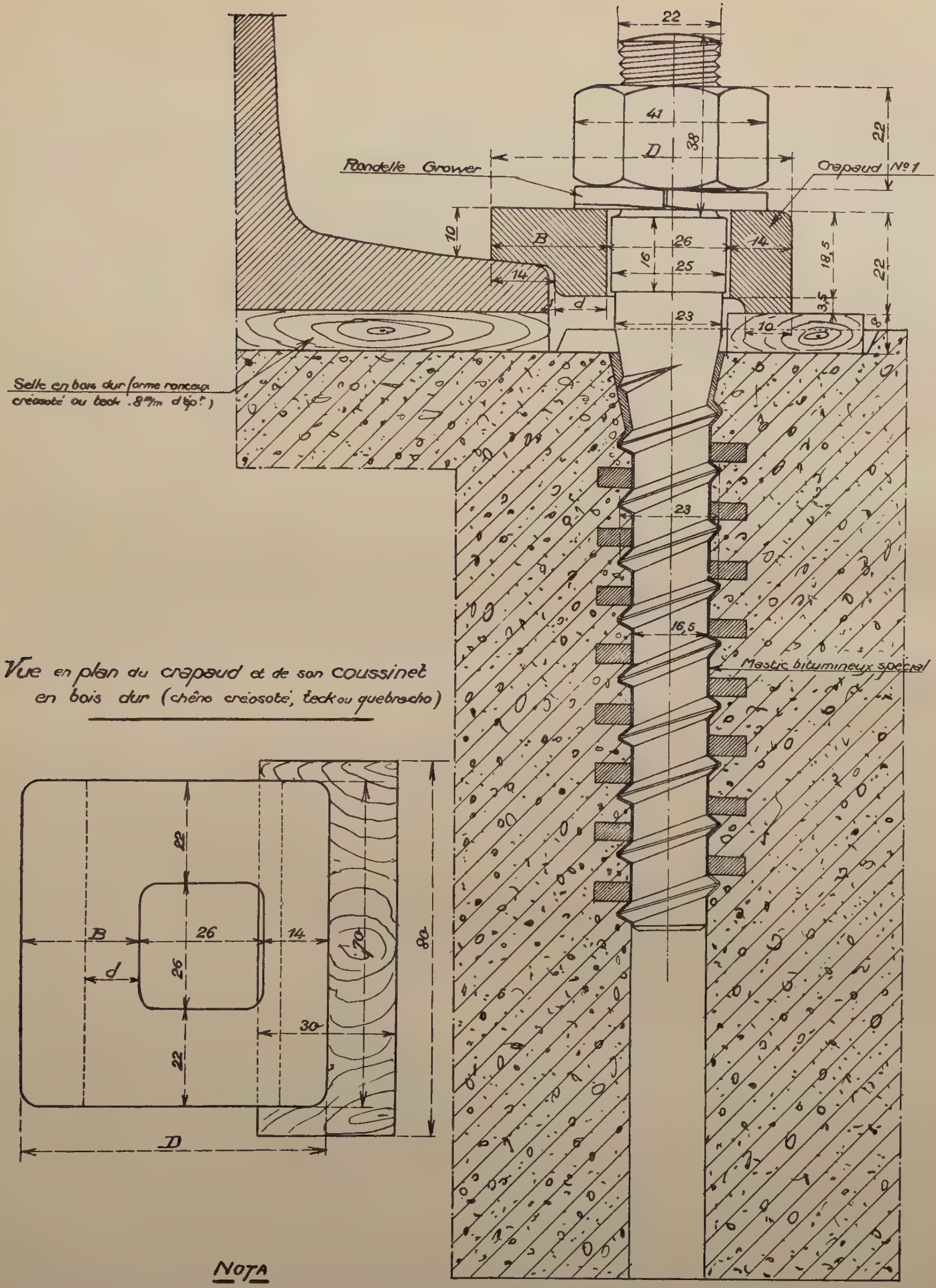


Fig. 8. — Coating coach screws with mastic.

If the coach screw is screwed in dry, it will end by slackening back, except perhaps when the play in the casting is very small, as the pitch of the thread is relatively small and the upper part of the thread is nearly horizontal (as in the case of the coach screws used on the Italian State Railways). As a general rule, the play left between the standard coach screw and the threaded hole is about 1 mm. (3/64 in.) which makes it possible to screw in without difficulty all coach screws of ordinary standards of manufacture, checked with the usual tolerances.

In order to prevent the slackening back of the coach screws, the following practice has been followed :

The line having been laid with the screws screwed into position dry, as a



Vue en plan du crapaud et de son coussinet en bois dur (chêne créosoté, teck ou quebracho)

NOTA

Le jeu de crapauds comprend le crapaud N°1 avec D = 65 m/m , d = 11 m/m et B = 25 m/m.
——— d° ——— N°2 avec D = 60 m/m , d = 6 m/m et B = 20 m/m

Fig. 9. — Ordinary fastening using a coach screw bolt.

Explanation of French terms : Crapaud N° 1 = Clip No. 1. — *Nota*. Le jeu de crapaud comprend etc.... = *Nota*. The set of clips, includes the No. 1 clip with D = 65 mm. (2 9/16 inches), *d* = 11 mm. (7/16 inch) and B = 25 mm. (63/64 inch) etc. The set of clips includes the No. 2 clip, with D = 60 mm. (2 3/8 inches), *d* = 6 mm. (15/64 inch) and B = 20 mm (25/32 inch). — Rondelle Grower = Grower washer. — Selle en bois dur (orme ronceux créosoté ou teck 8 m/m d'épaisseur) = Hard creosoted elm or teak packing 5/16 inch thick. — Vue en plan du crapaud etc.... = View in plan of the clip and its bearing of hard wood (creosoted oak, teak, or quebracho).

final operation the treating of the coach screws with bitumen is carried out, This consists in dipping the screwed end into a bath in which has been melted until it is as liquid as water, a special bituminous mastic (mixture of natural bitumen and hydrocarbons recovered from tar according to a formula which is a manufacturing secret).

The liquid product fills all spaces left between the coach screw and the threaded hole, and when cold again, becomes and remains elastic indefinitely. This mastic is sufficiently adhesive to prevent the coach screws from slackening back. Thanks to this method, ordinary coach screws can with perfect safety be used with the Vagneux sleeper, obviously a great convenience.

In practice, it is desirable that the coach screw used should have the shortest possible tapered collar as the screw only really begins to grip the concrete at the beginning of the threaded cylindrical part. For this reason in France, where the standard coach screw for wood sleepers has a long tapered collar, a special coach screw having the same thread, but with the screwed part longer, is used for concrete work.

It really means getting out a design for each type of track. From the practical point of view, the important thing is to see that the head is alike in both cases, so that the same tools may be used.

It is essential that the coach screw should be dipped in the mastic, and this is all that is needed to prevent the screw from unscrewing.

A slight play is left between the edge of the rail and the neck of the coach screw, as a result of which, it is possible, by using differently drilled sleepers, to change from one to another gauge differing by 5 mm. (3/16 inch). The junction of the two gauges is done in a rail length.

When a coach screw slacks back, a rare thing to happen, the cause is nearly always due to it having been badly coated with mastic. If during maintenance, loose coach screws are noticed, all that has to be done, is to redip them in the mastic.

A second type of fastening, designed by Mr. Vagneux, uses in place of the ordinary coach screw, a coach screw *bolt with a clip having a square hole.* The bolt consists of the lower part forming the coach screw, with a square neck, and above this again, an upper part, forming a bolt. The square neck fits into an opening of the same form in a clip one side of which bears on the rail like the clips of steel sleepers and the other through an extension piece, 10 mm. (3/8 inch) wide on a piece of hard wood placed on the sleeper.

A Grower washer has been shown in practice to be sufficient to prevent the nut slackening back.

So far as the threaded end of the bolt is concerned, it is as well to dip it in the mastic to preserve it against rust : it cannot unscrew except by taking the clip with it and this is impossible, seeing that it butts against the rail on a length of 70 mm. (2 3/4 inches).

There are two patterns of clips differing by the width of the part between the threaded portion and the edge of the rail.

By changing over the clips holding down the rail, the width of the track can be increased by 5 mm. (3/16 inch), and consequently using the same drilling of the sleepers it is possible to get three definite gauges, such as 1.440, 1.445 and 1.450 m. (4 ft. 8 23/32 in., 4 ft. 8 29/ 32 in. and 4 ft. 9 5/64 in.).

Insulating fastenings. — These fastenings are obtained in the Vagneux sleepers, by using ordinary coach screws or bolts, of the type described above, both one and the other being screwed into a special ferrule in hard wood, creosoted and impregnated with transformer oil.

The ferrule is pressed into a hole moulded in the sleeper.

Two or three threads of a Thiollier fiting embedded in the concrete, project beyond the cylindrical wall of this hole. The ferrule may be cut beforehand to suit the pitch of the thread of the fitting, but it is more usual to use a plain ferrule, into which the thread of the fitting is driven, either mechanically at the workshop, or by hand, and in case of isolated repairs in the track, by means of a special driver which encloses the top part of the ferrule. This top part projects above the hole in the sleeper : when the ferrule is driven home, the part projecting above the sleeper is levelled off.

The ferrule is slightly tapered, the diameter at the top being slightly greater than that of the hole. Driving it home results in the outside being compressed in addition to the inside compression caused by screwing in the coach screw.

As a result of these two factors, the resistance opposed by the ferrule against being torn out is very great (because it is screwed in) and there is little likelihood of it slackening out, or splitting (because it is held all round by the concrete).

The electric insulation of the rails, is ensured to a quite satisfactory extent, by the impregnated ferrule : in this respect, it matters little whether the fastening properly speaking, is by coach screw and even by spike, or by bolt.

The Vagneux bolt is, however, the ideal fastening to use with the ferrule, for the good reason that the clip with square hole prevents it from unscrewing. There is no need to re-tighten up. The mechanical wear of the wood by the thread of the coach screw, is thereby eliminated, and the fastening remains in good order as long as the wood itself remains sound.

If, however, spikes or coach screws are considered good enough, the ferrules must be renewed as soon as the wood is worn, and its tightness no longer certain. Partial replacements are made, and from time to time general renewals.

The operation is easy to do out on the line. First of all the rails are raised a few centimetres with jacks; the fastenings are undone, and the sleeper is pulled over first to one side, and then to the other, so as to give access to the ferrule, which is then screwed out, by means of a special withdrawer, without difficulty. The new ferrules are screwed into place, and the line put back into place.

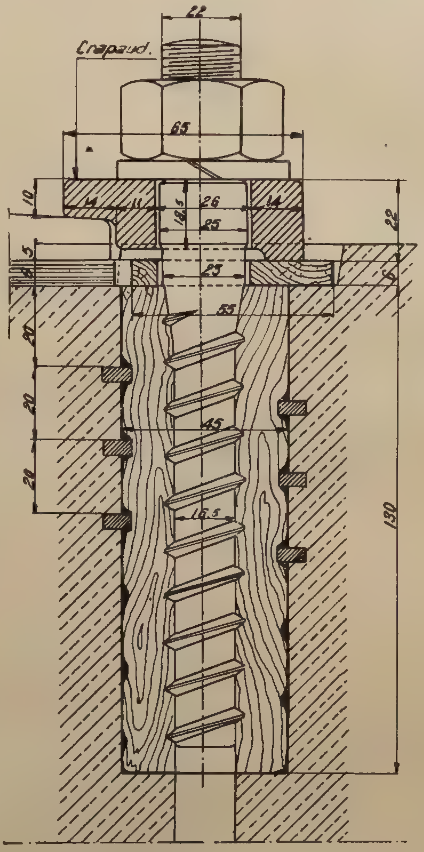
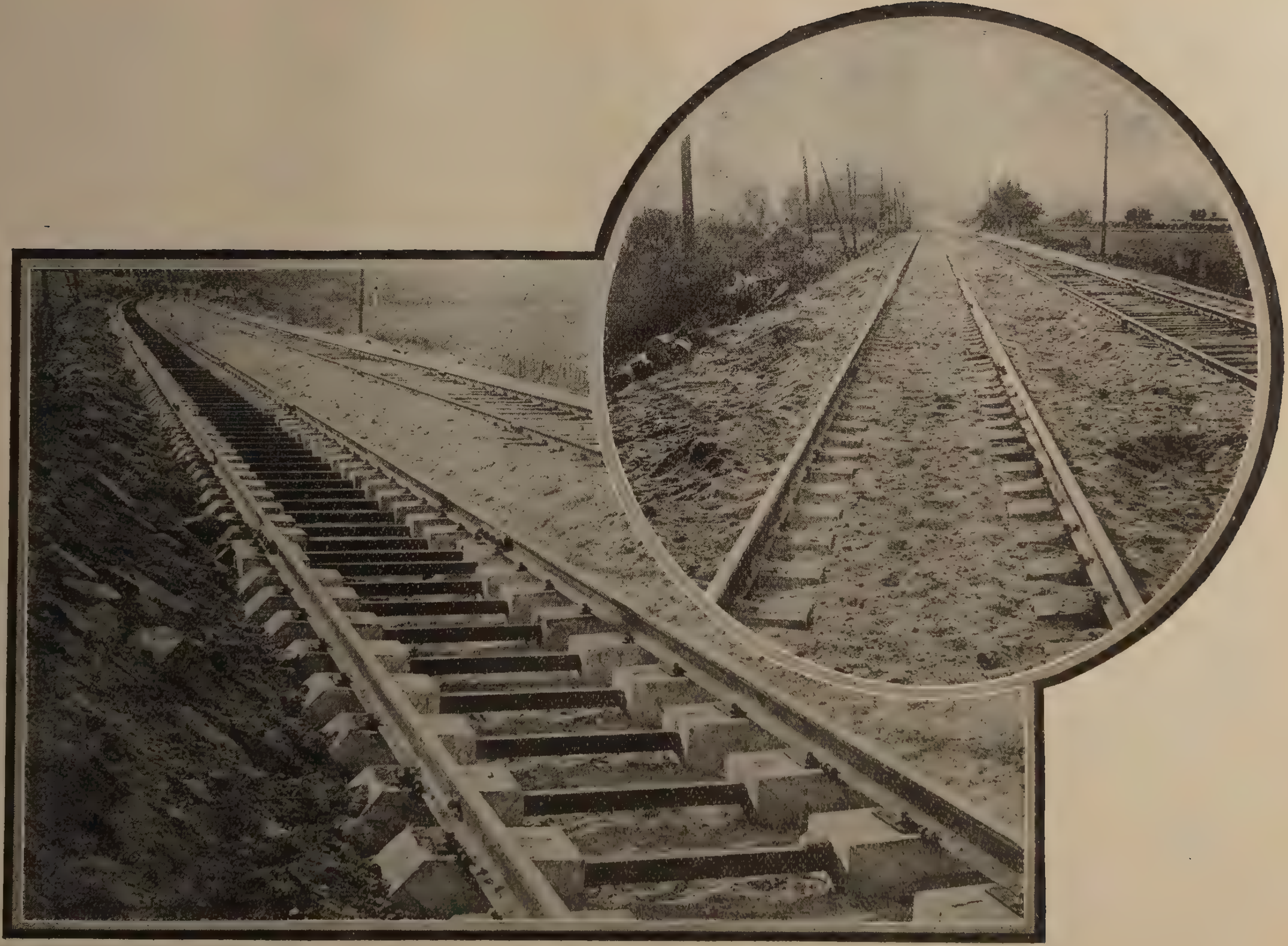


Fig. 10. — Fastening with coach screw bolt and ferrule (State Railways).



Figs. 11 & 12. — Northern Railway. Compiègne to Soissons line

Rather a lot of time has been given to the particular features of the Vagneux fastening using a ferrule, the use of plugs and some ferrules having been up to date, one of the many causes of failures of numerous designs of reinforced concrete sleepers.

Protection of the rail seat of the concrete. Sole plates.

The rail does not rest directly upon the concrete. The same is the case when metal sole plates, or chairs are used. Under the light hammering which the usual tightening up of the fastenings does not prevent, the grain of the metal when in direct contact, destroys the concrete on the surface, and the bearing of the rail gradually deteriorates. As a consequence, this bearing is protected by a wood packing of the same width as the rail foot the seat being sunk 4 to 10 mm. (5/32 to 3/8 inch) in the concrete to hold it.

The woods generally used for these packings are poplar, elm, and teak.

The poplar packings are not used as sawn : they are first of all compressed, which reduces the thickness 40 to 50 %.

Compressed in this way, and soaked when dry in tar, they give good service. The thickness after compression varies from 4 mm. (5/32 inch) for ordinary sleepers, up to 7 mm. (9/32 inch) for joint frames.

As the static load per unit of area, and the effect of shock are greater near the joints, it is more usual to use teak packings 10 mm. (3/8 inch) thick on the joint frames and the joint sleepers, compressed poplar or elm, which have to be creosoted or treated, being used on the ordinary sleepers, or on the blocks.

The present tendency is to suppress packings on these latter sleepers, and instead to apply to the concrete a protective material made from resin and bitumen. This coating covers up the rough surface of the concrete, and appears to be all that is needed to prevent the rail damaging it.

Metre gauge.

The Vagneux sleeper for metre (3 ft. 3 3/8 in.) gauge, naturally resembles that for the standard gauge : it is as it were a smaller edition.

Joint sleepers. — The question of the joints, however, is one of less difficulty, the special joint sleeper is more like the ordinary sleeper. The blocks are tied together by a single girder : they both have the shape of a longitudinal sleeper, when the line is laid with joints in line: the support is then known as a *symmetrical joint sleeper.*

When the line is laid with staggered joints, one of the blocks is the same shape as a longitudinal sleeper, whereas the other is exactly like the blocks of an ordinary sleeper : the support is then described as a *dissymmetrical joint sleeper.*

The ends of the rail bear on a large wood packing piece placed on the middle of the longitudinal sleeper. There are four fastenings per longitudinal sleeper.

Ordinary sleepers. — The ordinary sleepers are most usually of the composite type, the tie bar being either a 60 × 40 (2 3/8 × 1 9/16 inches) or a 65 × 32 (2 9/16 × 1 1/4 inches) or some similar section.

When, however, the formation is not subject to settling and the ballast is sand, a pattern, entirely of concrete, is often used. This sleeper is known as the flat bottomed sleeper, and the centre part is in the form of a narrow girder.

The ends, instead of being very closely symmetrical, with regard to the rail, are made rather longer towards the extreme ends.

As a result of this design, the bending moment set up in the central part by the uniform packing up of the sleeper, does not become too great. There is, there-

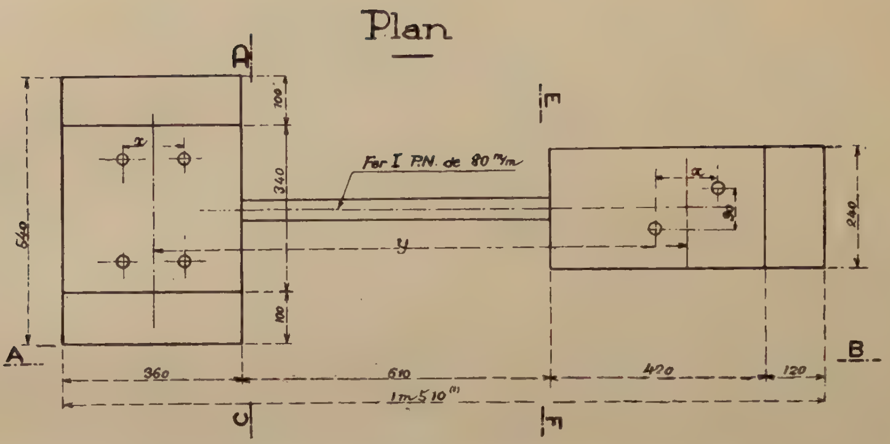


Fig. 13. — Dissymmetrical joint sleeper for metre gauge line.

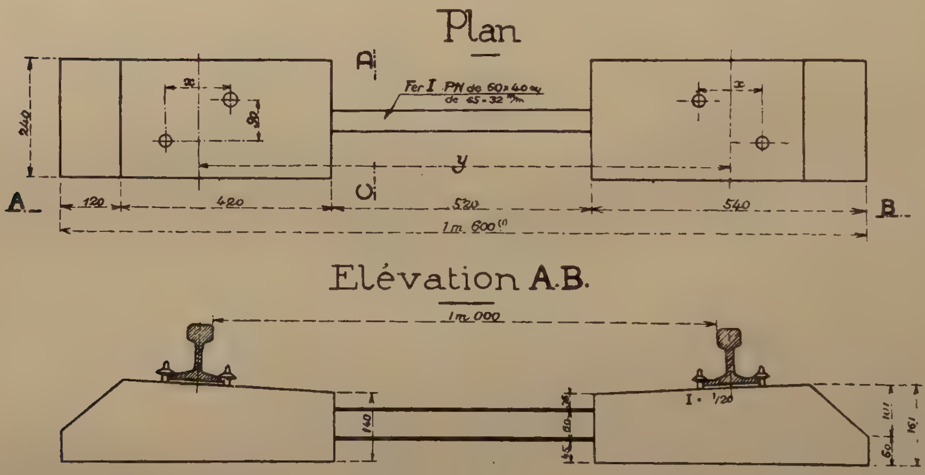


Fig. 14, — Composite sleepers, for metre gauge line.

fore, no need to dig out a centre trench, the sleeper giving good results : it is as well, however, not to fill the middle of the trench with ballast, until some time after the line has been laid. This statement does not in any way detract from what we have previously said, in connection with the rigid sleeper for the standard gauge track, the relative importance of the centre part not being of the same order of magnitude in the two cases.

Blocks. — It is unusual for the speed to exceed 60 km. (36 miles) on the narrow gauge. The need for the special cross tieing of the supports, therefore only exists on curves of small radius. For this reason, many narrow gauge railway systems using the Vagneux sleeper, follow the practice of laying pot sleepers alternatively with sleepers on straight sections. In curves of a radius equal to, or less than 100 m. (5 chains) the whole of the sleepers have cross ties. In intermediate cases, the track laying plan varies according to circumstances.

Fastenings. — The fastenings in the case of narrow gauge sleepers, are of the same patterns as for the standard gauge: the fastening using the coach screw bolt is rarely used. It is also unusual for the insulating fastening with a ferrule to be required.

The coach screw, that may be said to have become standardised by general use, is a hardened 23 mm. (29/32 inch) coach screw.

Manufacture of the sleeper.

Quality of cement. — Cement of good quality must be used in the manufacture of these sleepers. Artificial cement manufactured in rotary furnaces, from a mixture of clay and chalk, has always given good results. The same may be said of the super cements, the composition of which differ very little from that of the ordinary cements.

Vagneux sleepers have not been made from cement obtained by burning slag and chalk. Aluminous cement, tested at various times, has been completely given up as the result of observations which cast doubts upon the chemical stability of the products obtained.

Mixture. — The mixture of the concrete used for the sleepers varies according to the case, between 300 to 400 kgr. (660 to 880 lb.) of cement to 400 l. (14 cubic feet) of sand of 0 to 5 mm. (0 to 3/16 inch) grade and 800 l. (28 cubic feet) of small gravel, varying from 5 to 25 or 30 mm. (3/16 inch to 1 inch or 1 3/16 inches) or for 1 200 l. (42 cubic feet) of a mixture giving a finer concrete.

Period of drying. — The time to be allowed for hardening prior to the concrete sleepers being used, naturally depends upon the cement used. The strength of concrete, as we know, increases with age. We give further on the curves of the strength in compression, measured by the Laboratory of the *Ponts et Chaussées,* at Paris, on cubes of concrete having 20 cm. (7 7/8 inches) sides made with good slow setting artificial cement. These curves show that the strength increases nearly 40 % when the time is extended to 6 months, instead of 28 days.

The resistance of the concrete to shocks, and its adhesion to the steel, vary in the same way, but it would seem to an even greater extent.

It will therefore be understood how important it is that the sleepers should be as old as possible before they are put into use. In practice, standard gauge sleepers made from ordinary artificial cements, hardened in the open, are allowed 6 to 8 months to harden, and 4 to 5 months, in the case of metre gauge sleepers. By substituting super cement for the ordinary cement, these periods can be slightly reduced.

The hardening of concrete is hastened (and its final strength appreciably increased) by immersing the sleepers as taken out of the moulds, in water for 15 days to 3 weeks. The Cementi Armati Ferro-Tramviari Company at Milan, uses this process at the Elba works, where it manufactures Vagneux sleepers for the North of Milan Railway Company. These sleepers can be laid in the track three months after being taken out of the moulds.

Moulds. — The sleepers are moulded upside down, in moulds made either of metal covered wood, or entirely of metal parts, the moulds being detachable.

The sleeper moulds themselves are double. Following Mr. Vagneux's design, they consist of a frame of light girders, suitably stayed together, supporting the whole mould, a fixed middle partition and hinged sides. Locking bolts

Figs. 15 to 17. — Works of the Vienne Company at Mercins-Pommiers, near Soissons.

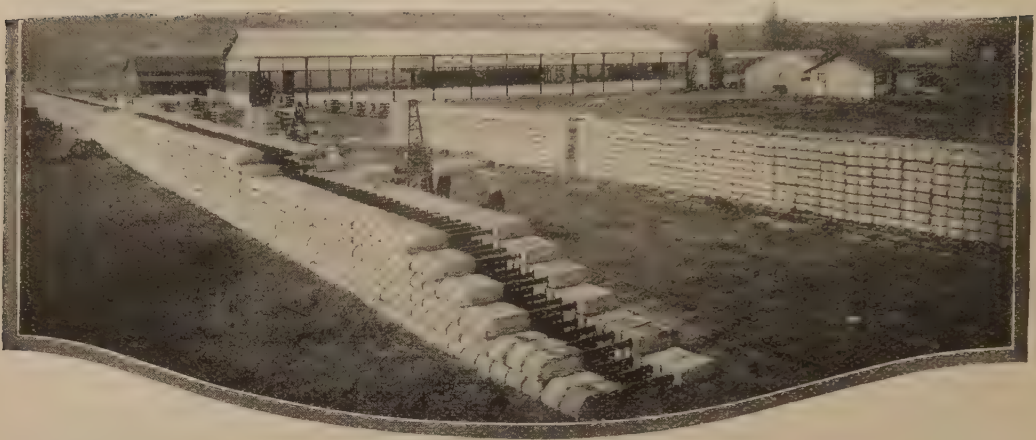


Fig. 15. - General view of the yard.

Fig. 16. — The concrete mixer and the jarring moulding machine.

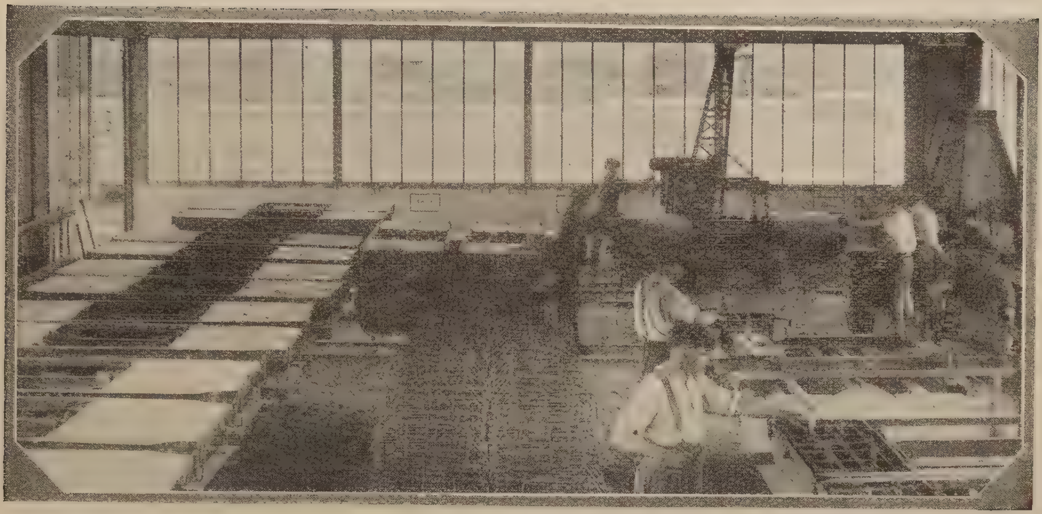


Fig. 17. — Removing from the moulds and taking away the supports.

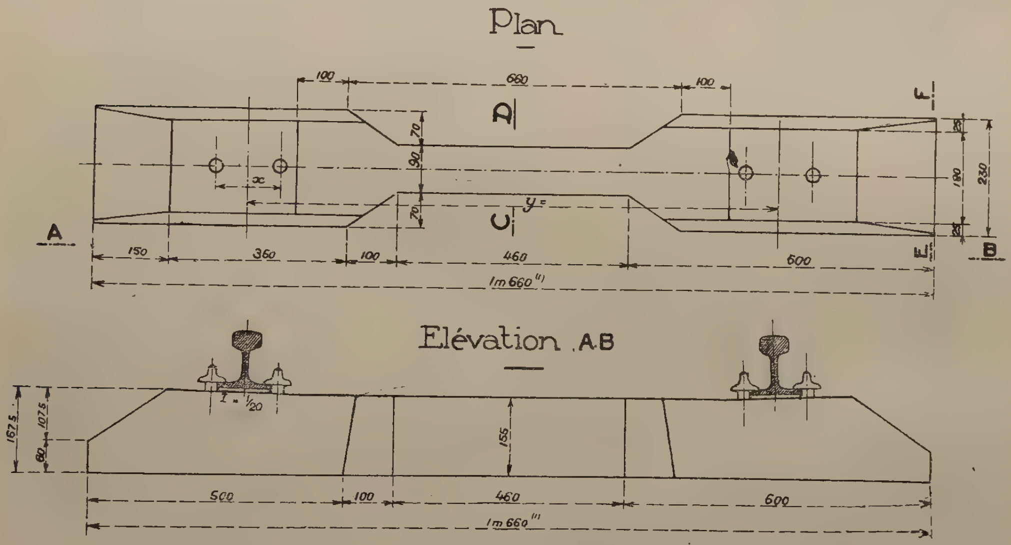


Fig. 18. — Sleepers with enlarged ends, for metre gauge lines (sand ballast).

secure the loose ends to the sides. Sleepers are removed from the moulds the day after pouring, when very finely ground super cements are used; after thirty six hours, or two days in the case of ordinary cement.

The ramming of the concrete, is done by hand in the small works.

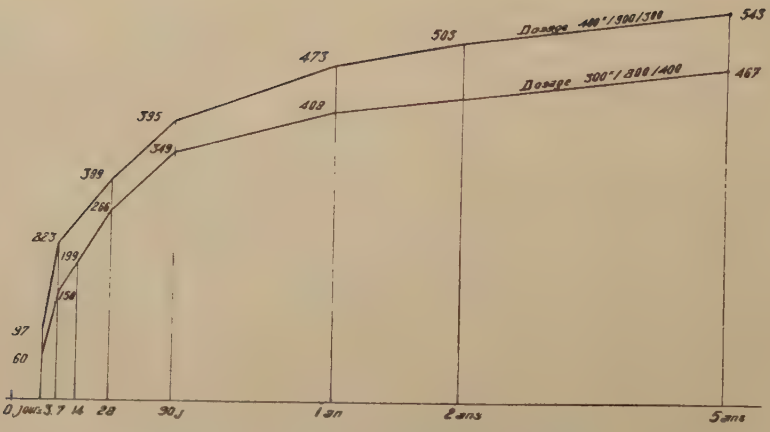


Fig. 19. — Strength in compression of cubes of concrete 20 × 20 × 20 cm. (7 7/8 × 7 7/8 × 7 7/8 inches).

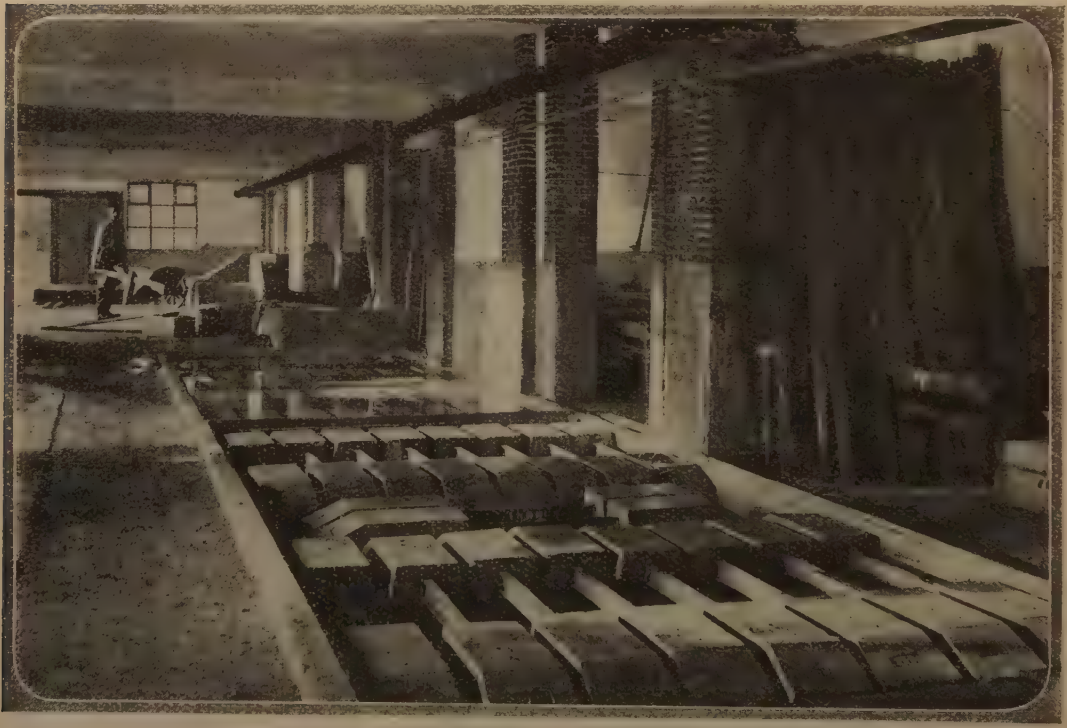


Fig. 20. — Italy, Erba works. Immersion of sleepers in water to accelerate hardening.

In large yards, the moulds are placed on tracks, of two rails, and slid on to the table of a jarring moulding machine designed by Mr. Jarrett-Knott, and made by Messrs. Maille & Company. The mould is raised a certain amount (which can be regulated) (10 to 15 mm. = 3/8 to 5/8 inch) at the rate of about 200 times a minute. The method gives a well mixed, very compact, and above all, a very strong concrete, and makes it possible to get excellent results with any class of labour available.

The machine rammer, was first of all used in the yards of the *Société anonyme de traverses en béton armé.* It is now found in the yards of most makers of Vagneux sleepers, and also in yards where other reinforced concrete parts are made.

The conditions governing the use of Vagneux sleepers.

The factors coming to be taken into account, when deciding if reinforced concrete sleepers can be used, are the following :

Kind of ballast;
Nature of the formation;
Speed of the trains.

Ballast. — The different materials used for ballast, from the point of view we are considering, differ in the size, hardness, and shape of their component parts, which should as a whole :

a) Ensure a sufficiently wide and uniform distribution of the vertical reactions (weights of the axles) of the longitudinal reaction (variations in the acceleration, brake applications) and transverse reactions (inscription of vehicles on curves, nosing, centrifugal force);

b) Enable the tamping to be properly done without much damage to the concrete.

The ballast can be coarser, if less hard, if it packs well, and if the largest pieces readily bury themselves in the smaller stuff.

As regards the use of reinforced concrete sleepers, ballast may be classified into three classes :

1st CLASS : *very good ballast :* sand, or mixture full of gravel and sand, which one could call gravel saturated with sand, broken stone passing a 4 to 5 cm. (1 9/16 to 2 inches) ring.

2nd CLASS : *useable ballast :* broken stone, passing through a 6 or 7 cm. (2 3/8 to 2 3/4 inches) ring in all directions, according to its hardness. (For example 6 cm. [2 3/8 inches] for granite and hard lime stones, and 7 cm. [2 3/4 inches] for soft limestone).

3rd CLASS : *unsuitable ballast :* round gravel (clean or mixed with a little sand) broken stone passing through, according to its hardness, 6 or 7 cm. (2 3/8 to 2 3/4 inches) rings.

Now that the sleepers can be tamped by mechanical means, and the track maintained by tamping with the shovel, a practice much favoured now on certain railways, the above classification, is less rigid.

There is, however, no doubt but that it is very advisable to use, whenever possible, a ballast which is suited to the sleeper, or sleepers which suit the ballast.

Formation. — The uniform distribution of the reactions, is obviously more difficult to get when the ballast is carried on rock formation, than when on earth. There is then danger of broken stone ballast forming hard spots. For this reason, it is essential not to use concrete sleepers on a rock formation, unless the track can be ballasted with fairly fine material (1st class above).

Speed. — Vagneux sleepers have stood up under the highest speeds authorised in France (120 km. = 75 miles an hour).

They can therefore be used without any limitation of speed, with ballast of the first class, and up to speeds not exceeding 90 to 100 km. (56 to 62 miles) when suitable stone ballast is used.

Financial aspect of the Vagneux sleeper.

The financial comparison between sleepers in reinforced concrete of the Vagneux system, and wood or steel sleepers, would be grossly misleading, if only the cost of the sleepers themselves were considered. The comparison must include, for the various systems, on the one hand, the cost of establishing the complete formation, including the supports, the fittings (fish plates, packing, coach screws or bolts, and clips) and the ballast, and on the other hand, the corresponding annual amortization and maintenance costs.

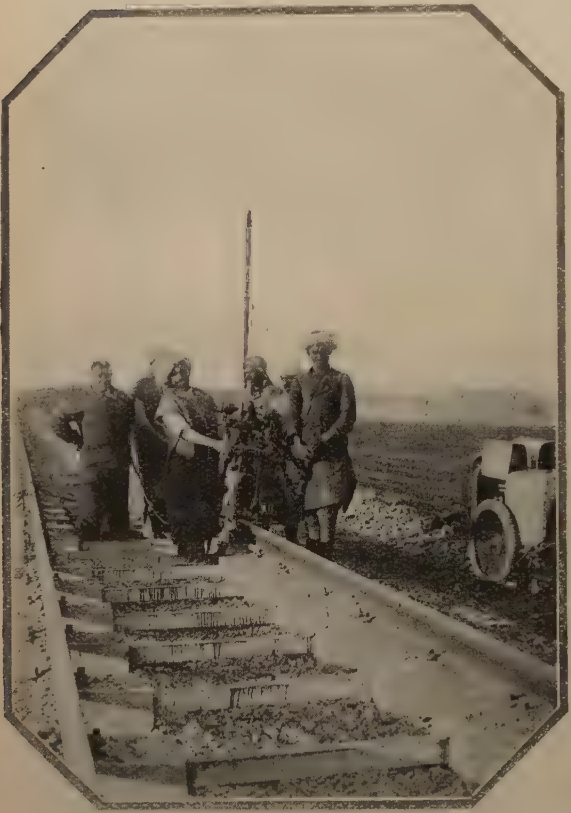


Fig. 21. — Oran to Oudjda line (Paris-Lyons-Mediterranean Railway, Algerian lines). Laying track on Vagneux sleepers.

First cost. — The prices of reinforced concrete sleepers obviously depend upon the current prices of steel and cement, sand and gravel, labour, the type of fastening, and above all, on the quantity ordered, over which the cost of the works and moulding plant can be spread.

The *average* price in 1928, of the Vagneux sleeper, for standard gauge, made in quantity, can be taken at 55 francs in France for the bare sleeper itself, and at 62 francs for the fully fitted sleeper (2 packings in poplar and 6 special coach screws with the mastic to coat them).

The 1st class sleeper in creosoted oak (5 kgr. = 11 lb. of creosote) costs about 40 francs, or 45 francs, with 6 standard cocah screws and the creosoted beech sleeper (18 kgr. = 39 lb. of creosote) about 50 francs, or 55 francs, with 6 coach screws.

As for the steel sleeper of the pattern adopted in France, it costs 58 francs, and 67 francs, with fastenings.

The joint frame costs double the price of the sleeper.

The pair of blocks, or pots, costs about half the price of the sleeper (that is 28, to 30 francs, for the bare blocks, and 33, to 35 when fitted up).

The cost of laying a track with reinforced concrete equipment is rather higher than when wood or steel sleepers are used, by about 30 to 40 % in the case of standard gauge, and 20 to 25 % on the metre gauge.

The Vagneux sleepers enable an appreciable saving in ballast to be effected: the concrete sleepers, as a rule are only 2.20 m. (7 ft. 3 in.) long, instead of

2.60 m. (8 ft. 6 1/2 in.); they butt into the ballast on the inside faces of the ends; they are heavy. For these reasons, the width ballasted can be reduced, and about a quarter of a cubic metre of ballast can be saved per metre (1/4 cubic yard per yard).

This saving makes good the extra cost of the Vagneux sleepers, and of laying them, in comparison with wood sleepers.

It increases the saving in cost as compared with the steel sleeper.

When dealing with a secondary line on the straight, or a station siding, where the blocks can be laid alternatively with the ordinary sleepers, the first cost of using Vagneux sleepers is below that with new wood sleepers.

Annual amortization and maintenance cost. — Creosoted wood sleepers last about twenty years, but to get them to last so long, they have to be carefully looked after and repaired, especially as regards cleaning up, or renewing the rail bearing surfaces, repairing the fastenings, making them good, or renewing them. The cost of these repairs, generally carried out a number of times after the sleeper has been in use ten years or so, represents 15 to 25 % of the cost of the new sleeper.

The steel sleeper lasts about thirty years, according to German statistics. The cost of upkeep is very great, owing to the constant need for tightening up the fastenings, and from renewing them from time to time.

If the life of reinforced concrete sleepers cannot be determined from official statistics, owing to their recent introduction, it is possible to form some idea of it from the following simple argument :

As sound concrete becomes increasingly harder with age, if a sleeper has stood up without fracture for ten years, and for four years, on lines with 50 to 60 trains per 24 hours, as in the case of certain lines laid on Vagneux sleepers in 1918 and 1924 respectively, this sleeper, may be said to have a probable life of 100 or 40 years, when only 5 or 6 trains run over the line daily. It is therefore reasonable to expect, today, that the Vagneux sleeper will fast fifty years on lines of average traffic.

This sleeper requires no other maintenance than the replacement of the worn packings, and the redipping of any fastenings found to need it.

The improvement in the joint, given by the joint frames, or joint sleepers, and the perfect balancing of the packed surfaces in relation to the rails, result in lines laid on Vagneux sleepers remaining in good condition.

The conclusion can be drawn, that the Vagneux system of reinforced concrete sleeper, whilst meeting the shortage of wood sleepers, forms an important advance in laying permanent way, and makes it possible, when used in conjunction with suitable ballast, to obtain important savings in maintenance.

[625. 143 .2]

The manufacture of sound rails.

(*Le Génie Civil.*)

The article by Mr. Pichard and the letter from Mr. Charpy, published in the 31 December 1927 and the 10 March 1928 numbers respectively of the *Génie Civil* (1), have again drawn attention to the important problem of the manufacture of sound rails and of its solution « by a division of the ingot not at right angles to its longitudinal axis, but parallel thereto, in order to follow the piping and, consequently, to reduce the proportion of sound metal rejected in the discard ».

Mr. Charpy adds that « the segregation being absolutely unavoidable, it can be conceived that one can with advantage resort to the costly process of completely eliminating the central part of the ingot » and reveals thereby a divergence between his ideas and those of Mr. Courthéoux who, according to Mr. Pichard, proposed « to tolerate metal of indifferent quality at the middle part of the rail foot whilst the wings of the foot would be of sound metal »: the segregation would appear under the foot which normally works in tension, and there would be in consequence danger of fissuration and even of sudden breakage in a part of the rail section practically impossible to supervise in the track. It is therefore the complete elimination suggested by Mr. Charpy that is to be preferred instead of simply dividing the ingot along its main axis.

It should, however, be noted that a discard parallel to the axis of the ingot would be equivalent to punching out the centre of the individual cheeses from which tyres are to be made: it was thought formerly that this punching out of ingots roughed down into cheeses would be sufficient to completely eliminate the piping and impure metal; but macrographs of sections of tyres made in this way and broken under the drop test or in service shew that they still contain the initial commencement of fissures and some segregation. These observations have caused some makers to alter the shape of small ingots in order that the discard may be made before roughing out under the hammer or press and prior to punching out the middle.

We ought to add that if it is possible by a longitudinal discard to eliminate the piping, it is not always possible to remove thereby the impurities which may be spread throughout the ingot or be thrown up over the outside skin (2).

The above considerations lead us to doubt the absolute efficacy of the procedure suggested by Mr. Charpy. The effects of piping and segregation, and their elimination, have none the less been under the attention of both makers and users for a long time.

As regards rails, the papers by Professor Tetmayer published by the *Schweizerische Bauzeitung* in 1896, and the translation thereof in the July 1897 number of the *Bulletin of the Railway Congress* should be reread.

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(1) See also *Bulletin of the Railway Congress Association*, July 1928, p. 550.

(2) See *Génie Civil* of 24 March 1928, p. 282, and the *Bulletin of the Railway Congress*, February 1929, p. 168, the article by Mr. Frémont (figs. 6 and 7) and the *Génie Civil* of the 7 April 1928, p. 333, as well as the *Bulletin of the Railway Congress*, November 1928, p. 916 : « Central white stain in rolled ingots », by Mr. Viteaux (fig. 2).

Professor Tetmayer, even at that date at the conclusion of his investigation had prescribed, as the leading method of controlling the manufacture and prior to all other tests, corrosion or etching tests, in order to eliminate rails « the texture of which caused doubts as regards the possible occurrence of splitting, scaling, or longitudinal fissuration ».

In 1900, Osmond, after having set down the general laws of ségregation previously indicated by Pourcel, wrote that « the final distribution of the impurities depends upon the pouring temperature, the viscosity of the liquid, of the more or less active agitation produced by the escape of the gases or by artificial methods, and from external causes which affect the speed of cooling »; competent metallurgists, he added, naturally find in the proper use of these different methods means for reducing or removing from their finest products the effects of segregation (1).

A little later, the question was raised in the United States of requiring for rails a heavy discard, as in the case of guns. Professor Howe thought it more rational to endeavour to reduce the segregation either by using better metal or by more suitably shaped ingot molds or by improved methods of pouring (2). Professor Howe has shewn, for example, by ingenious tests, that the piping is less important and that the effects of segregation shew themselves as a rule at the top of the ingot, when using ingot molds of maximum section and upwards, and when the cooling off of the ingot is slowed down near the top by means of an ample discard head.

The remarkable work carried out by Sir Robert Hadfield followed, and resulted in his method of producing sound ingots and rails, the subject of many articles, pamphlets, etc., extracts of which or translations have appeared in the *Revue de Métallurgie* (1).

This eminent metallurgist first of all recorded that « the manufacturer finds himself in a dilemma : if he produces steel which does not give a central piping or cavity, the steel is not sound : if he produces sound steel he gets a centre cavity as dangerous as the segregation ».

It was therefore a question of keeping the steel in the top part of the ingot molds in the liquid state a fairly long time so as to allow for the filling up of the piping in measure as it occurs in sound steel.

Sir R. Hadfield arrived at this result by burning in contact with, or at a short distance from, the surface of the liquid steel a solid fuel, such as charcoal, by means of a compressed air blast : the combustible is separated from the metal by a layer of fusible slag which prevented the loss of heat by radiation (2).

The loss through the discard with Hadfield ingots is 8 % whereas it exceeds 25 % when the ingots are simply poured with the smaller end downwards, and

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(1) See the paper given by Osmond before the Commission on the methods of making tests (2nd session, 1900, Vol. II, p. 4, section A : metals).

(2) See *Revue de Métallugie*, May 1908, p. 236, article signed by H. L. C., and p. 321 : *On the influence of the conditions under which steel ingots are poured, upon the formation of blow holes and segregation*, by Howe.

(1) See the *Revue de Métallurgie*, April 1913, p. 485, Hadfield. *The production of sound steel ingots and the revelation of segregation in steel ingots.* — P. 499, Bibliography. — P. 507, Hadfield. *New method of ascertaining the segregation in steel ingots.* — P. 517, Gruner. *The establishment of a works with a view to the production of sound ingots by the application of the Hadfield process.*

See also July 1915 number, p. 597, Hadfield and Burgess. *Ingots and rails of sound steel.*

(2) The Hadfield process was specially considered in the *Génie Civil* of the 3 July 1915 (Vol. LXVII, No. 1, p. 1).

18 % with the same ingots with unheated discard heads.

The many metallographical tests carried out on Hadfield ingots have shewn that « the whole of this metal is sound without piping, segregation, or other defects ».

One of Sir R. Hadfield's conclusions, which agrees with that of Professor Tetmayer, is : « If one limits oneself to tensile and shock tests, no serious difference will be found between sound and unsound rails. On the other hand, the metallographical examination is of valuable assistance in determining the quality of rails »; let us add that during recent years the metallographical examination has become more general as a result, especially of the very valuable investigation of Mr. Frémont on the corrosion tests of irons and steels published in 1908 and 1927 and summarised in this journal (1).

In parallel with the investigations carried out with a view to improving the methods of pouring, enquiries into the addition, at the furnace or in the ladle, of alloys and of special metals to obtain a more perfect refining of the steel continued to be made : important results were obtained in this way by using ferro-manganese, ferro-silicon, aluminium, ferro-titanium, ferro-chromium and nickel (2).

The conclusion can be drawn from this sketch of the first stages of the investigations made during recent years, that it appears to be possible to obtain sound rails by combining the known processes for eliminating piping with a suitable refining of the metal; it is by this means that the content of impurities is reduced to minimum, and, in consequence, their concentration in a more or less important part of the rail section; it is this concentration, revealed by metallographical examination, that is described as segregation by the users of the rails.

The complete elimination of piping and segregation so defined is now achieved in a number of Works : we were able to note this personnally during a number of visits thereto recently.

MERKLEN,
Special reporter to the 1925
Railway Congress.

* * *

Having communicated the above note to Mr. G. Charpy, we have received from him the comments given below :

The Editor of the *Génie Civil,*

I have to thank you for having forwarded me Mr. Merklen's note dealing with « the manufacture of sound rails ». It recalls a whole series of principles upon which I have frequently written in your columns, and which as a result I feel I ought not to discuss again : I limit myself to referring to these articles. In one of the most recent, which you were good enough to publish in the 26 May 1928 number, I said « When one wishes to remove them (the breaks in continuity resulting from piping and blow holes) one knows very well how one should act. » This is almost exactly the conclusion of Mr. Merklen's note. However, I think it would be wise, even at the present time, to limit statements of this kind to particular and well defined cases. The users are legion; they do not always succeed in indicating what would give them satisfaction in a sufficiently precise manner for these wishes to be translated into workshop formulæ; and in fact, arguments with regard to supplies continue to be numerous and unending.

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(1) See the *Génie Civil* of the 22 and 29 October 1910 (Vol. LVII, Nos. 25 and 26) and of the 28 January 1928 (Vol. XCII, No. 4) and the pamphlets, Nos. 28 and 71, of Mr. Ch. Frémont.

(2) Visitors to the « Blöcke und Halbzeug » stand at the Berlin Exhibition (Metal constructional materials, October-November 1927) were able to observe that homogeneous steel (ordinary commercial quality) could be obtained by the correct use of ferro-silicon.

The particular case of rails is each day the subject of new articles in the French and Foreign Technical Press, and the composite Commission formed two years ago by the French Railway Companies, whilst actively carrying out its work, does not disguise the fact that the investigation it has been required to make will be long drawn out, and that it would be dangerous to endeavour to shorten the enquiry period.

The undoubted difficulty met with in defining the qualities that should be considered necessary, and the means of obtaining them surely, is evidently due to the causes of anomalies being many and often very imperfectly characterised.

There is, for example, a real lack of a definition of the word *segregation*. It really appears that most often it is used as synonymous with the French word *liquation*, that is to say, variation from one point to the other of the ingot of the chemical composition : the analysis of samples taken at various points alone can completely characterise this phenomenon, which is absolutely unavoidable in a steel ingot. If we be content to note the effects of a chemical reagent on the different points of a prepared section from an ingot, these effects, never definite quantitatively, will differ according as they have been attacked with weak acid solutions, iodine, copper reagents of the Stead type, or by the Baumann process. In which cases could one say the steel is sound ? This remains a matter of individual appreciation.

Other particular features, such as blow holes, inclusions, very fine pipings, etc., correspond to certain quite special conditions of formation and distribution, and should be considered separately. Thus it is certainly exaggerated to say, for example, that « the tests made on Hadfield ingots have shewn that the whole of the metal is sound and free from piping, segregation, or other defects ».

I have had the occasion to make various tests on the Hadfield process, some of which have been published by Sir Robert Hadfield himself, and I have been able to observe that, as was to be expected, the localisation of the piping did not result in the disappearance of the phenomena of liquation, inclusions, etc.

The same thing applies, moreover, to the different processes recommended for the improvement of the structure of the ingots : each of them acts in general on one of the causes of heterogeneity, but not on the others.

It is therefore necessary to beware of extrapolations, and to investigate separately each particular case. In this way the likeness between longitudinal sectioning and punching of ingots, as made by Mr. Merklen, does not appear to me to be of any value. As a matter of fact, ingots for tyres are subjected in turn to operations which act in the other direction; first of all they are flattened out along the vertical axis in order to form cheeses or rings : during this deformation the piping enlarges, and as it occupies a large part of the section of the ring, it is not surprising that the punching, which only removes a small portion of metal about the axis, does not always completely get rid of this enlarged piping.

On the other hand, in the method of rolling I have described, the alteration in form of the metal always takes place in the same direction and tends to bring the piping towards the centre, so that it can be affirmed that a moderate central discard will have a certain, whilst not absolute, efficacy. Tracing the successive forms taken by the metal in the two cases enables us to underline easily this difference which moreover is verified by all macrographic tests.

In a general manner, it seems difficult to deny that the fact of having eliminated the axial part of the ingot, which is necessarily and always a region of weakness, forms a useful method, if we are endeavouring to approach the ideal, that of a perfectly sound metallurgical product.

I have already had occasion to recall the fact that in certain especially important cases, such as the plugs of common shell, the naval artillery service does not hesitate to have recourse to heroic measures and to prescribe that « the steel for the plugs shall be from ingots *parted cold along their longitudinal axis* and shall have all parts affected by piping, by serious defects or by groups of slight defects removed and discarded. ». A method of rolling which makes it possible to get similar results by a less costly method than by parting cold forms therefore an appreciable step in progress, the more worthy of being taken into consideration as, without any difficulty, it can be superimposed on all other methods for improving the ingots, none of which alone has an efficacy that can be considered as absolute.

G. Charpy,
Member of the Institut de France.

Mr. Merklen, to whom we sent this reply, requested us to follow it by the few lines below which we insert to close this controversy.

1. Our definition of the segregation appears to avoid « the real indetermination » attributed by Mr. Charpy to the meaning of the word.

We know, furthermore, that the processes of corrosion generally used to reveal the segregation (iodine, hydrochloric acid, Heyn and Baumann reagents), give results which are in agreement.

2. I think I have indicated in a correct manner in what Sir R. Hadfield's invention consisted : it is a process consisting in the reduction of the extent of the piping and which does not entail through the process alone, « the disappearance of the phenomena of liquation, inclusions, etc. »

As I wrote, Sir R. Hadfield had first of all shewn that « the manufacturer finds himself in a dilemma : if he produces a steel free from any central cavity, this steel is not sound : if he makes sound steel, he gets a central cavity just as dangerous as the segregation ».

By combining his method of eliminating the piping with a suitable refining and slow cooling of the metal, Sir R. Hadfield has succeeded in producing « sound metal free from piping, segregation, or other defects ».

[621. 133.7 (.42) & 725 .33 (.42)]

Water softening for locomotive boilers.

London and North Eastern Railway instals new plant at Annesley.

Figs. 1 to 4, pp. 414 and 415.

(*Modern Transport.*)

It is now generally realised that one of the most essential features in railway work is the efficient softening of the feed-water for the locomotives, to prevent both scale and corrosion. The results of recent detailed investigations in the United States have shown in rather startling fashion the serious losses caused in the running of railways because of feedwater troubles, while the subject has long been a problem of the first magnitude both on the Australian and South African Railways, for example. The remedy, of course, is to soften the water at the depots and deliver it ready for use to the locomotives, with not more than from five to six degrees hardness and also slightly alkaline, which eliminates all the difficulties. There has recently been set into operation a new water softening plant on the lime and soda ash principle at the London and North Eastern Railway Company's locomotive depot at Annesley, near Nottingham. Supplied by the Paterson Engineering Co., Limited, of Windsor House, Kingsway, W. C. 2, according to the latest practice and specially designed for the difficult local conditions involving a high content of magnesium salts, the plant is arranged for a maximum hourly duty of 10 000 gallons.

Principles of treatment.

It is well known that two main principles of treatment can be adopted for water softening, the use of base exchange materials and lime and soda ash. Whilst opinions differ considerably on the subject as regards boiler feed purposes the lime and soda system is usually employed, especially for locomotive practice. Thus mud, iron, acid and (when used hot with any exhaust steam) dissolved gases, are eliminated without adding strongly alkaline sodium bicarbonate to the water, which causes priming in the boilers, while the calcium and magnesium salts can be reduced to an extremely low figure, about 3-5° total hardness, which does not give any appreciable film of scale. In order to obtain the best results, however, with the lime cream and soda ash process it is necessary to have equipment that includes an efficient type of automatic feed mecanism for supplying the chemical reagents to the water. In fact, this very largely determines whether a water softening plant is in practice easily adjustable, free from breakdowns, and requires the minimum care and attention — all very important items. From this point of view, one of the most interesting reagent feed gears is the by-pass « Osilameter » type of the Paterson Engineering Company, as supplied with the new plant at Annesley.

A new feed gear.

The design of the « Osilameter » feed gear is neat and effective, and, as seen in figure 2, the inlet hard water flows at

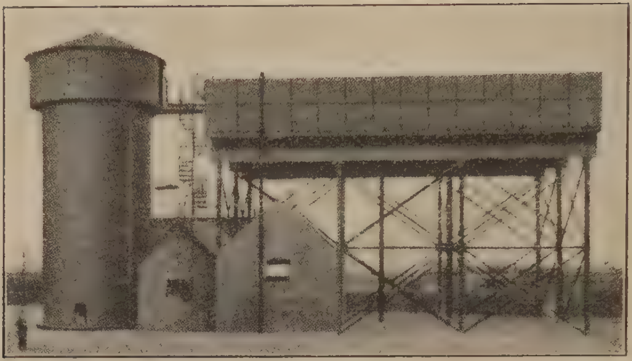

Fig. 1. — The Paterson water softener and storage tank installed at the Annesley locomotive depot, London and North Eastern Railway.

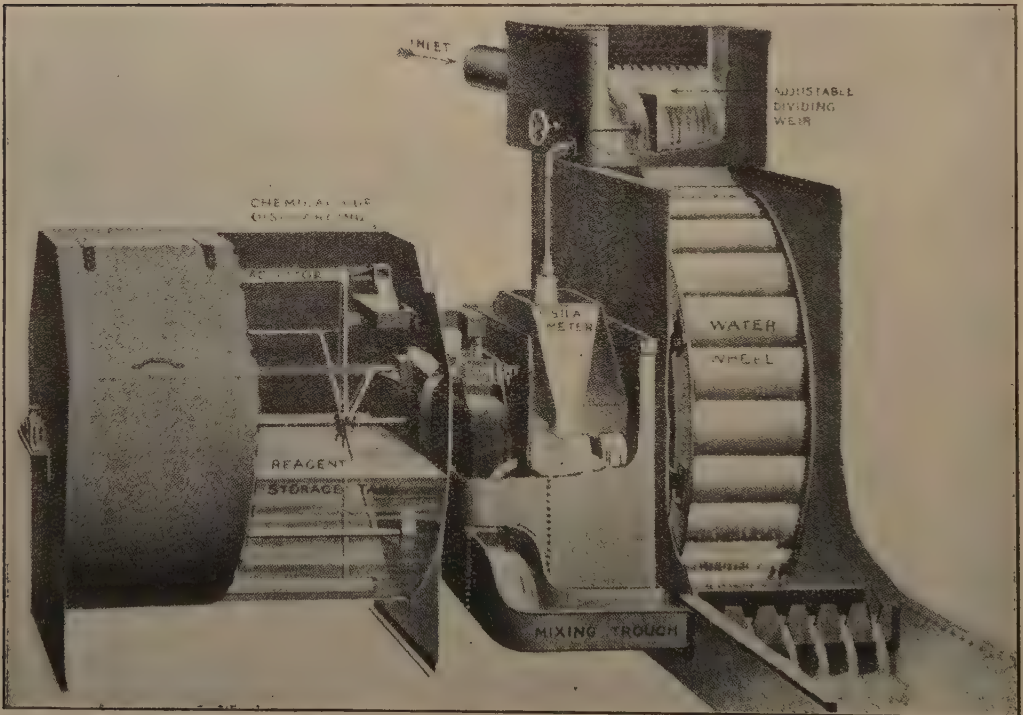

Fig. 2. — The Paterson water softener : « Osilameter » chemical feed gear.

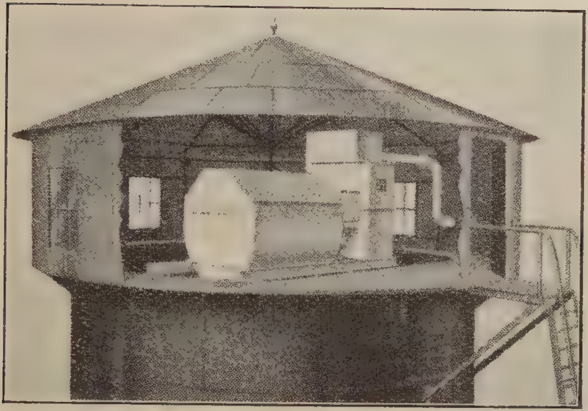

Fig. 3. — The Paterson water softener; housing and proportioning gear.

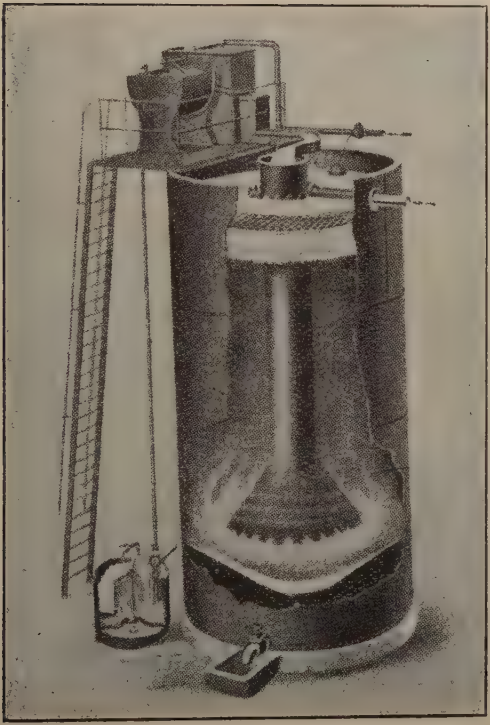

Fig. 4. — Section through the Paterson water softener.

the top of the plant into a small longitudinal chamber containing a weir, which is divided by a vertical plate or partition, movable horizontally to and fro by the simple operation of a hand wheel so as to divide the flow of water over the weir into two portions. The larger part of this flow, generally about 80 % of the total, passes out and operates a vertical water wheel which discharges the water into a short horizontal trough passing down into the central reaction and precipitation pipe of the plant, the revolutions of the wheel being utilised to work an agitator in the lime and soda ash container, or storage tank, so as to ensure that the reagent is always of uniform strength without any settling of the lime. The smaller portion of the flow from the weir, that is about 20 % passes into a small tipper, or « Osilameter », divided into two compartments, so designed that when one of these is filled with the water the « Osilameter » overbalances by the weight, thus emptying out the water, which then flows to the small mixing horizontal trough and joins the main flow from the water wheel. At the same time, this « Osilameter » operates small buckets which, by means of a series of cups at the ends of the agitator shaft, are always kept filled with reagent, the arrangement being that, as the « Osilameter » tips over, a bucket of reagent is at the same time discharged into the water. The cups on the agitator shaft, as they rotate, dip under the surface of the reagent, are filled and then lifted up, being then emptied out into the reagent buckets, which are thus always kept full, the excess flowing back into the container, while no lime can lodge in the cups. In this way the chemicals are first thoroughly mixed with 20 % of the unsoftened water passing through the « Osilameter », and then with the main flow of 80 % of the water from the turbine wheel, before passing into the central reagent pipe of the plant, which, in this case, has also a special mechanical agitator.

Simplicity of the design.

As usual, the reagent liquid is made up with lime and soda ash always to one standard strength, and the above design ensures, in the first place, that it must be added in a definite relation to the total flow of the water no matter how this may vary, since if the volume is increased, the amount of water passing over the weir is increased and the « Osilameter » operates quicker, and *vice versa*. If it is desired to alter the definite percentage of the reagent as required by the varying hardness of the water, this is accomplished in the simplest possible manner by merely turning the hand wheel at the top of the plant and adjusting the position of the vertical plate or division in the weir. As a result, a greater or less percentage of the total flow of the water is diverted to the « Osilameter » and operates it more quickly or more slowly in proportion, so that more or less chemicals are added according to whether the water has become harder or softer. In this ingenious manner all complications, such as laborious hand adjustment of screws or taps and alteration of the capacity of the cups, are obviated, while the fact that only about 20 % of the total flow of the water passes through the « Osilameter » mechanism reduces shock and wear and tear to minimum, whilst, as an added precaution, special spring buffers are provided.

The tank.

The chemically treated water after leaving the « Osilameter » gear is conducted by a trough to the central tube of the reaction and precipitation tank (fig. 4), where it is stirred up by a constantly revolving frame agitator operated by chain drive from the spindle of the main water wheel. This tank measures 18 feet in diameter and is 37 feet in height, allowing over five hours for the completion of chemical reaction and deposition of the impurities from the water, which flows downward through the central pipe. The softening process is completed and the remaining suspended matter removed by passage upwards through a specially prepared wood fibre filter bed. The hardness forming and other impurities thrown into suspension by the chemical process are collected in a specially designed box, 4 feet in diameter and 2 feet deep, at the base of the precipitation tank, from which the sludge is abstracted at regular intervals through a control valve. As will be seen in the general view in figure 1, the whole plant is covered by galvanised iron housing formed over the top of the reaction tank, the design of which is shown more fully in figure 4. We understand that the plant described in these notes is identical to a water softener of 10 000 gallons hourly capacity which was supplied some years ago by the Paterson Engineering Company to the Pretoria locomotive depot of the South African Railways and Harbours Board, and has given extremely satisfactory results.

CURRENT PRACTICE.

[385 .4 (.68)]

1. — Changes in the general organisation of the South African Railways.

The report of the South African Railways and Harbours for the year ending the 31 March 1928, mentions some important alterations in the management of this system, which were brought into operation on the 1 April 1928.

We call attention to them below in the words of the report itself.

The Railways and Harbours in South Africa have grown rapidly since Union. This expansion has rendered necessary a review of the system of control. As a result, the railways are now divided into nine separate systems, each system being controlled by an officer with the title of System Manager, who is responsible directly to the General Manager at headquarters.

The System Managers have the same powers as were previously exercised by Assistant General Managers in charge of the systems under the old organization, and the area over which each System Manager has jurisdiction, covers substantially the same ground as that of the late divisions. The new systems are as follows :

SYSTEM.	Headquarters.	Railway mileage controlled at 1st April, 1928.
Cape Western	Capetown.	1 678
Cape Midland	Port Elizabeth.	1 252
Cape Eastern	East London.	1 124
Cape Northern (including Bechuanaland)	Kimberley.	1 458
Orange Free State	Bloemfontein.	1 540
Natal	Durban.	1 686
Western Transvaal	Johannesburg.	994
Eastern Transvaal.	Pretoria.	1 601
South-West Africa	Windhoek.	1 770
	TOTAL.	13 103

The area of the country served by the railway mileage shown above, is 795 000 square miles, approximately equal to the united areas of France, Germany, Switzerland, Belgium, Austria, Hungary, Holland, Norway and Sweden.

Each System Manager has on his staff a System Engineer, who advises him technically on all civil engineering matters and, working under the direct control of the System Engineer, are District Engineers who are in charge of the maintenance districts of the system. The designation of Assistant Superintendent (Maintenance) has been abolished.

Each System Manager has a mechanical officer to advise him on the mechanical side of the work; also an officer to supervise the operating work of the system, while on the more important systems there is, in addition, a superintending commercial officer. Thus each system is self-contained, the separate sections of the work being controlled by civil engineering, mechanical engineering, operating and/or commercial officers.

With regard to telegraphs and telephones, signals, train lighting and electric power work, the new organization provides for these services, as affecting each system, being handled directly by the System Manager concerned and his technical officer, and reference to headquarters in regard to such matters is made only whenever it is necessary to obtain special technical advice or instructions on questions of principle.

A greater measure of direct control of the railway police than under the previous method of organization, has been vested in System Managers, and this applies also to the tarpaulin and sail repairing depots.

The reorganization has necessitated certain changes in the organization of the General Manager's Office. Two Assistant General Managers, with headquarters at Johannesburg, have been appointed to assist the General Manager in connection with the technical and the commercial and operating work of the railways and harbours.

In the allocation of administrative responsibility, while the Assistant General Manager (Technical), on behalf of the General Manager, attends to civil, mechanical and electrical engineering matters as well as to those affecting stores, works and estates, signalling, telegraphs and telephones, the Assistant General Manager (Commercial) is responsible for the work in connection with trains, rolling stock, general, rates, claims, road motor transport, tourist traffic, harbours, shipping, catering, publicity, grain traffic and lost property and excess goods depots.

The Engineering Department has also been reorganized. The post of Assistant Chief Civil Engineer has been abolished; the office of Maintenance Engineer, which previously existed at Capetown, Bloemfontein, Durban and Johannesburg, is no longer necessary under the new organization, and two Inspecting Engineers have been appointed on the personal staff of the Chief Civil Engineer to carry out inspection work on open lines on his behalf.

In the Mechanical Department the position of Assistant Chief Mechanical Engineer has been established and his duties include, more especially, the control under the Chief Mechanical Engineer, of the several mechanical workshops and, to some extent, of the Transportation running depots as far as the mechanical work is concerned.

The Chief Electrical Engineer has been transferred to the General Manager's staff at headquarters.

As a tentative arrangement, the control of the Transportation expenditure offices has been transferred to the Chief Accountant. It is expected that the change will enable a greater degree of supervision and control of financial matters.

The changes outlined will generally facilitate the business of the railways and should lead to economy.

The chief officers of the Administration at Headquarters meet the General Manager every morning in the Boardroom when all important railway matters are discussed and a course of action indicated.

[621 .33 (.54)]

2. — The electrification of the Bombay suburban section, Bombay, Baroda and Central India Railway,

By H. E. Sir Leslie Orme WILSON, P. C., G. C. I. E., C. M. G., D. S. O.

Fig. 1, p. 421.

Early history of suburban development in Bombay. — Bombay has suffered in a similar manner to other cities owing to lack of adequate housing accommodation, and being an island without any scope for expansion, it has necessarily been compelled to extend in a northerly direction. It was in 1881 that the alarming percentage increase in the population became so apparent that the question of suburban development could no longer be ignored. It was quite evident also that unless some relief was afforded at that time to the population, this state of affairs would go from bad to worse. History does not relate why no action was taken at this period to improve matters in the suburban areas and in fact it was not until quite late in the succeeding decade, when plague had visited the city and caused deplorable mortality, that an Improvement Trust was established to control and direct the development of Greater Bombay as it is doing to-day. It would hardly be correct perhaps to say that there had been no exodus to the suburbs prior to 1881, though it was at this stage in the history of the city that large numbers began to seek the sources of relief afforded by the two large railway concerns serving Bombay. They sought, very naturally, for localities which while at a safe distance from the overcrowded areas of the city, were still within convenient reach by the local train services. It may be assumed without fear of contradiction that accessibility was the governing factor in the plans devised for building in the suburban areas, and it may be assumed also that healthy surroundings entered largely into the question. To the east and north-east of the island there were certainly many healthy sites for selection, but for the majority these were not at the time considered to be quite within easy reach of the city. On the Bombay, Baroda & Central India route geographical conditions were exceptionally favourable, not only because of the proximity of the seaboard, but also because the habitable localities were at a convenient distance from the city. It was in 1881, therefore, that the Bombay, Baroda & Central India Railway can claim to have attained its preliminary importance in the matter of a suburban train service — a circumstance which must largely be attributed to the unfortunate epidemic which occurred during that year and which, strictly speaking, gave the first great stimulus to suburban migration from the city. Since then the local train service has continued to grow at a remarkable rate, so much so indeed that it represents a very large portion of the Bombay, Baroda & Central India Railway undertaking and has severely taxed the resources of the railway. It is believed that no other railway in India has so large and so well patronised a suburban service as the Bombay, Baroda & Central India Railway has to-day, a feature of which is the steady progressive increase and development of the enterprise over the past half century.

Statistics of passenger traffic. — Prior to 1888 there is no record available to show the number of passengers who made use of the suburban train service, but in that year the total amounted to 10 millions — a figure which serves as a useful datum in reviewing the statistics of more recent years. In 1914 the numbers carried amounted to 24 million, in 1918 to 30 million and to-day the numbers are 38 million. During the boom period in 1922 when rents had risen to an excessive figure in the city there were no less than 45 million passengers carried thereby causing a severe test on the capacity of the section which at that time had none of the modern equipment for the acceleration of train movements afforded by track circuiting and train control. Such a rapid increase in the number of passengers carried naturally caused no little anxiety to the Company who recognised that to provide the public with the facilites necessary for an efficient service a conversion from steam to electric traction would be necessary as it was obvious that by this means only could a satisfactory solution to the problem be obtained. Many preliminaries including the quadrupling of the tracks between Grant Road and Borivli, the remodelling of most of the local stations, the installation of track circuiting over the entire section of 23 miles and the substitution of over-bridges at important crossing points, where formerly a level crossing had been sufficient to deal with the traffic, were necessary, however, before any definite progress could be made in the matter of substituting electric power for the existing steam locomotive.

Preparation of estimates for the electrification scheme. — Although, as pointed out, it was in 1920-1921 that the number of suburban passengers had increased to such a large extent, it was in 1912 that the Great Indian Peninsula and Bombay, Baroda & Central India Railways invited Mr. Merz through their respective Boards of Directors in London, to investigate and report on the feasibility of improving the local railway communications between the City and the suburban districts by means of electrification. The consideration of Mr. Merz's report was unfortunately delayed by the outbreak of War in 1914 and had to be postponed until after the cessation of hostilities, by which time operating conditions had become so difficult and the congestion of the existing services so great that no doubt remained as to the justification of the large expenditure required to accomplish a scheme of such magnitude. The preparation of revised estimates and plans were completed in 1923 and submitted to the Secretary of State of India who accorded his approval to the expenditure of approximately two crores of rupees for the purpose of electrifying the two local tracks between Church Gate and Borivli. It was subsequently found necessary to include in the scheme the electrification of the two « through » tracks between Grant Road and Bandra and also, as a temporary measure, the section between Church Gate and Colaba.

Duration of the work. — According to the original scheme it was hoped that the electrification of the suburban train service would have been completed in 1926. Owing, however, to the necessity of first completing the quadrupling of the tracks the probable date of opening had to be postponed to April 1927. Contracts for the electrification materials and equipment, etc., required for the Bombay, Baroda & Central India Railway were placed in 1925, but owing to the unfortunate circumstance of the coal strike which occurred in England during 1926 considerable delay was caused in the execution of these contracts, with the result that it has not been possible to introduce the electric service until now.

Some technical details in connection with the supply of electric power and its distribution. — The whole of the power required for the operation of the electric

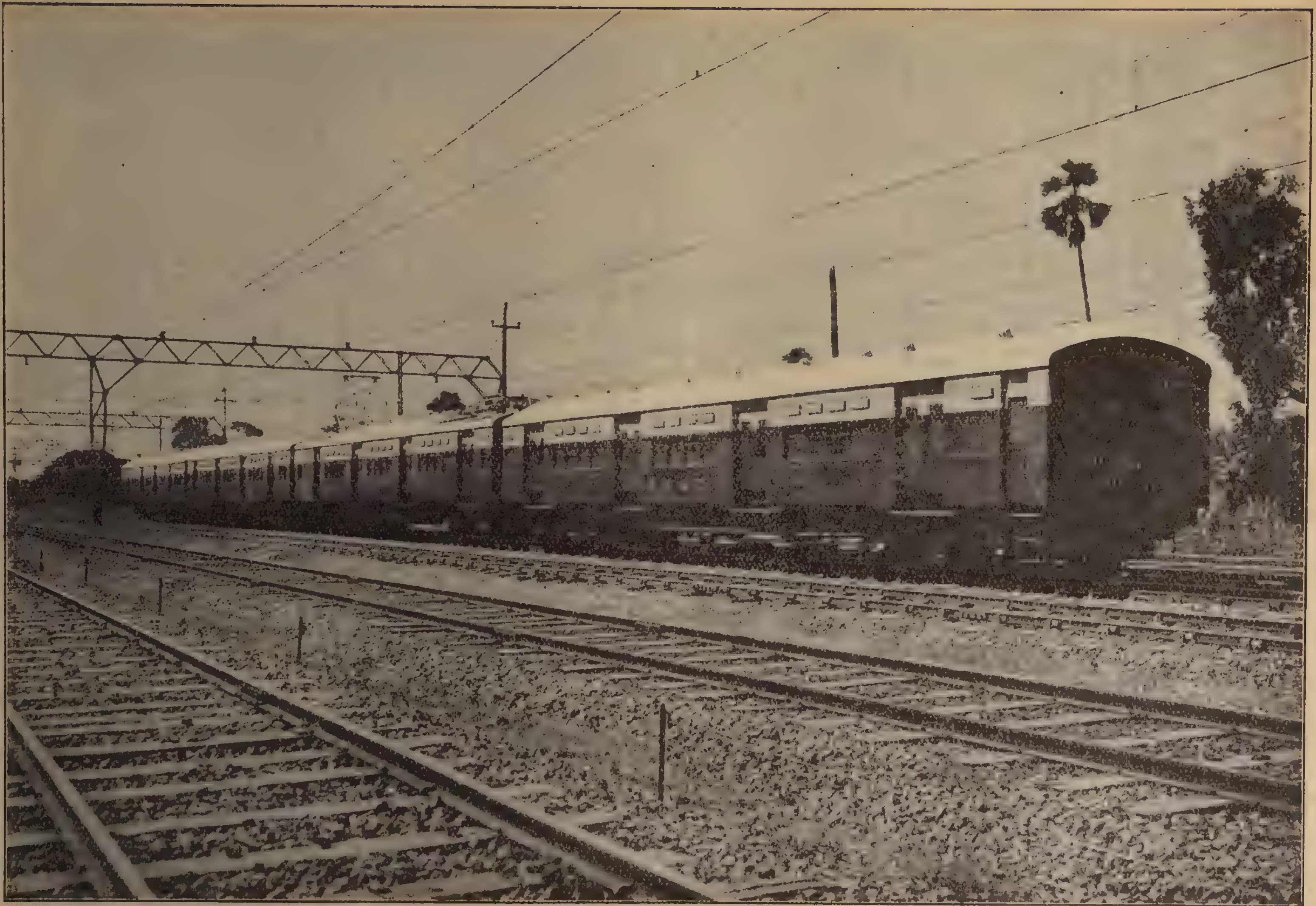

Fig. 1. — An electric train unit of four coaches.

service is obtained from the hydro-electric generating stations controlled by Messrs. Tata Sons Limited,which are situated in the Western Ghats some 100 miles distant from Bombay.

The power is transmitted to Bombay in the form of three-phase alternating current, with a pressure of 110 000 volts and a periodicity of 50 cycles per second and is received at the Dharavi receiving station, where it is transformed down to a pressure of 22 000 volts for supply to the railway sub-stations at Grant Road, Bandra and Kandivli. The supply to Grant Road and Bandra is by means of duplicated underground cables and to Kandivli by overhead transmission lines, also in duplicate.

At the sub-stations the supply pressure of 22 000 volts is stepped down by static transformers to 560 volts, at which pressure the current is fed to rotary converters, which convert it to direct current at 1 500 volts for supply to the overhead transmission lines from which the trains draw their supply. The sub-stations at Grant Road and Bandra are each equipped with 3 sets of rotary converters and 2 similar sets are installed at Kandivli. Each set consists of two separate machines, each having an output of 1 250 kilowatts at 750 volts direct current and the two machines are run in series to provide the required line pressure of 1 500 volts direct current.

In addition to the main transformers, the sub-stations are equipped with smaller transformers which step down the voltage from 22 000 to 2 200, at which pressure a supply is taken along the line for station lighting and auxiliary purposes.

The sub-stations are controlled from a Control Office situated between Bellasis Bridge and Mahalakshmi Station, from where it is possible to start or stop any one of the 8 converter sets. No attendants are required at the sub-stations, except for periodical cleaning and overhaul.

The sub-stations are replete with the latest apparatus for the control and protection of the machinery installed in them.

The system adopted for electric traction purposes is known as 1 500 volts direct current with overhead contact wire. Two wires are suspended from suitable insulators fitted to the steel overhead structures which span the tracks. The upper wire known as the catenary has considerable sag between the structures and from this catenary the contact wire is suspended by means of droppers which serve to maintain the contact wire at a uniform height above rail level. This contact wire is suspended above the centre of the track being slightly staggered so as to obtain even wear on the collector. To prevent it being affected by wind velocity it is secured to the structures by means of a « register arm » attached to a cross span wire. On the curves pull-off wires are attached to the catenary to bring the contact wire over the centre of the track, these pull-off wires being attached to the masts by suitable insulators. The overhead contact equipment is fed from the sub-stations at a pressure of 1 500 volts direct current and at certain points section switches have been inserted in the contact and catenary wires to enable a faulty length of overhead conductor to be isolated if required. The sub-stations themselves have been equipped by Messrs. Metropolitan Vickers, Limited with rotary machines which are automatic in operation and are under remote control of the Power Supervisory Headquarters located at Bellasis Road. From these sub-stations the current is conveyed to the train motors through the pantograph collectors, the bows of which press against the contact wire. The current having passed through the train motors returns to the sub-stations through the rails which have been specially bonded at each joint by heavy copper conductors so as to ensure an easy path of return. The total registered horse power of the machinery installed in the sub-stations is 27 000 and the underground transmission and distribution cables have a total length of 39 miles. The Consulting Engineers in the matter of all electrical equipment for the overhead conductors, sub-station machinery and traction equipment were Messrs. Merz and McLellan, now Messrs. Merz and Partners.

Some interesting facts in connection with the new electric stock. — A most important item in the programme of the electrification scheme was the provision of entirely new coaching stock of the latest all-steel fire-proof pattern. The bodies of these are of strong yet light construction, being built up of plates, rolled sections and pressings securely rivetted together. The method adopted for building up the sides is one which has been patented by Cammell Laird & Co. with whom the order was placed for constructing the coaches. The design allows for the free circulation of air between the inner lining and the outer shell, efficient insulation being provided thereby, whilst condensation, which is so often the cause of corrosion in enclosed spaces, has been entirely eliminated. The coaches are equipped with wide sliding doors constructed of aluminium alloy suspended on « Crittal » runner bars with guides at the bottom working in grooves formed by the sill plates. The door locks have been specially designed to permit of maximum door openings. Wind screens are provided for each doorway and there is a vertical handpole in the centre of the coach. The underframes have been designed so as to accommodate the electric motors and are of the sole-bar carrying type; they are built of rolled steel sections and plates securely rivetted together. The buffing and draw-gear is of the M. C. B. pattern and smooth running is ensured by the use of suitably sprung cast steel bumpers. The complete electrical equipments for these coaches have been supplied by the British Thomson-Houston Company, Limited. Each motor coach is equipped with four 1 500/750-volt direct current ventilated interpole railway motors rated at 275 H. P. at 700 volts on the one hour basis. They are 750-volt motors insulated for 1 500 volts and each pair of motors on each bogie is permanently connected in series, the two pairs being connected in parallel. As it frequently occurs that the track is flooded during the monsoon to a depth sometimes of 2 feet or more, the motors have been designed to be water-tight and solid covers are provided to replace the open covers over the air inlet and outlet during this period.

The interiors of the coaches are lined with teakwood throughout and the seats of the third class coaches are also of teak. In the upper class carriages the seats have been made up on well sprung steel frames of the « nesta » type. The rolling stock comprises 160 coaches in all, of which 68 have already been received in India. The coaches will be coupled up in units of four — one motor coach and three trailers — and these units can be run separately, or coupled to form full trains of 8 coaches. The seating capacity of an 8-coach train is sufficient to accommodate about 1 000 persons, and is 33 % greater than the capacity of the existing steam trains. Each motor coach is equipped with four motors, having a combined rating of 1 100 H. P., which are capable of accelerating a fully loaded train unit of four coaches at the rate of one mile per hour per second. It is, therefore, possible to attain a speed of 30 miles per hour within half a minute of starting.

The control equipment provides for automatic acceleration, thereby enabling the « motorman » to concentrate his attention on the signals. In the driver's compartment are fixed the master controller, the 110-volt auxiliary circuit control switch panel, the vacuum exhauster and the vacuum exhauster controller.

The master controller is fitted with a « dead man's switch » and pilot valve for operating the brake emergency gear.

These coaches are 68 feet long and 12 feet wide as against 10 to 10 1/2 feet, the width of the steam stock. Owing to their exceptional size it was impossible to consign any of the coaches by rail to any port in England without dismantling them previous to their departure from the Works of Cammel Laird & Co. at Nottingham. It was necessary, therefore, to devise some other method of transport and the problem was satisfactorily solved by the decision to convey the coaches to Hull by water, an operation which was facilitated by the proximity of the river Trent to the works at Nottingham. The shipping of completely erected rolling stock to India is not new. It will be remembered that the Bombay, Baroda & Central India Railway imported many of its largest locomotives some years ago in a similar manner. The site selected on the Trent for loading was less than a mile from the works and fortunately the route thereto was practically an ideal one, being free from gradients and devoid of excessive street traffic. As completed, each coach was transported from the works on road bogies specially designed for the purpose and hauled to the river wharf by a traction engine. On arrival at the wharf they were deposited in barges by means of a 40-ton crane and from thence were conveyed to the King George Dock at Hull, a distance of almost exactly 100 miles. At the Docks the coaches were lifted from the barges by means of a 70-ton crane with slings similar to those employed at Nottingham. The subsequent conveyance of the coaches and their delivery in Bombay was entrusted to Capt. Christen Smith, who designed two special motor vessels specifically for the purpose and accompanied the first consignment personally to ensure efficient handling and safe delivery. The painting of the carriages and internal fittings have been completed in the Company's carriage shops at Parel and the entire rolling stock was built under the supervision and to the designs of Messrs. Rendel Palmer & Tritton, Consulting Engineers to the Company.

[656 .1 (.42) & 656 .2 (.42)]

2. — Great Western Railway makes agreement with road undertaking.

Prior to the passing of the Railways (Road Transport) Act 1928, British Railway Companies had no right to own or operate road motor vehicles, except as feeders to railway stations. Besides this restriction, they were also legally prevented from entering into agreements with road transport undertakings, so that any form of organised co-ordination between road vehicles and the railways was virtually impossible. This state of affairs did not minister to the best interests of the country, and it is not surprising that in 1927 the British Railways applied to Parliament to obtain powers for two specific purposes. Firstly, to be able to own and operate motor vehicles themselves, and secondly, to obtain powers to enter into agreements with Local Authorities and private motor transport firms with a view to bringing about co-ordination and the most economical use of the lands and property of the railway company.

After a detailed enquiry, the main-line railway companies obtained the powers sought for, and the Railways (Road Transport) Act 1928 was passed last year.

Already the Companies have taken advantage of their powers with regard both to the running of road motor vehicles themselves, and to entering into agreements with road transport firms.

One of the most important examples of the latter is an agreement which has recently been made between the Great Western Railway and the National Omnibus and Transport Company, details of which will now be given.

Under this agreement, an altogether new company has been formed, namely, « The Western National Omnibus Company, Ltd. » On the board of this new company the Great Western Railway and the old National Omnibus and Transport Company has equal representation. The first Chairman of the Board is Sir John Jarvis, hitherto associated with the motor undertaking.

The agreement covers a wide area in the western counties of England, whereas the authorised capital of the new company amounts to £1 000 000.

Among the benefits which are expected to result from this agreement are the following : First of all, there will be a considerable extension of through booking facilities as between villages served by motor bus services only, and railway stations in other parts of the country. Secondly, under the new agreement an improved service will be given to the public, in the form of greater frequency of service, and the giving of services along routes hitherto not served.

Other advantages expected are those usually associated with agreements such as this, such as synchronisation of timetables, joint advertisement, and so on.

Besides this large scheme for co-ordination, the Great Western Company has purchased certain road motor companies outright.

Services hitherto operated by the Dare Valley Company, between Aberdare, Hirwain and Merthyr, are now owned and operated by the Great Western Railway; also, services hitertho in private hands, operating between Newport, Usk, Monmouth and Pontypool Road are now in the hands of the Company. Agreements have been made between other motor operating companies and the railway company, making tickets inter-available as between road and railway services.

An arrangement, similar to that made with the National Omnibus and Transport Company, is being made with the South Wales Commercial Motors, Ltd.

So far as freight is concerned, the Great Western continues to extend its motor lorry services; among the more important traffic dealt with may be mentioned bricks, sand, machinery and agricultural produce.

[656 .1 (.42) & 656 .2 (.42)]

4. — An agreement between the London, Midland and Scottish, London and North Eastern Railways and the Sheffield Corporation.

Another example of the way in which British Railway Companies have taken advantage of the powers obtained under the Railways (Road Transport) Act 1928, is an agreement made between the London, Midland & Scottish Railway, the London & North Eastern Railway, and the Sheffield Corporation Tramways Committee, *i. e.*, a local government or municipal service.

In this agreement, the railway companies are to acquire a half interest in a large number of motor bus routes, and are to be in full ownership of others. Omnibus routes in the City of Sheffield, for the purposes of this agreement, are to be divided into three classes, namely :

a) those routes which both commence and terminate within the city boundary;

b) those which extend for short distances beyond the city;

c) comparatively long distance runs connecting Sheffield with neighbouring cities.

With regard to *a*), these will not be affected, and will continue to be operated by the City Corporation. In the case of class *b*), the railway companies are to purchase a part of the capital assets now employed by the Corporation, so that the railway companies' financial interest in the services operated will be equal to that of the Sheffield Corporation. As to class *c*), the railway companies are to purchase all capital assets employed on the present long distance routes. These latter routes are operated from Sheffield to Bakewell, Barnsley, Buxton, Doncaster and Huddersfield.

The joint services classed as *b*) will continue to be actually operated by the Corporation, but will nevertheless be subject to the control of a Joint Committee on which there will be representatives of the railway companies and the Corporation. The vehicles will bear the names of all three parties concerned. In this way, a degree of co-ordination of services will be brought about between road and railway services.

The services classified under *c*) will be both owned and operated by the railway companies. The latter will give employment, under the conditions which apply to all other railway employees in Great Britain, to those hitherto in the service of the Sheffield Corporation, but who might have been displaced under such an agreement as this.

Both the railway companies and the Sheffield Corporation undertake not to inaugurate either themselves, or in conjunction with any other company, any additional services in the Sheffield suburban area without a mutual agreement. This arrangement has been made for a period of ten years, after which it may be terminated on either side at twelve months' notice.

It is far too early to estimate the success of these services, but the agreements as described above clearly illustrate their nature and importance.

MISCELLANEOUS INFORMATION

[625 .13 (.42) & 621 .392 (.42)]

Strengthening of bridges by electric welding.

Figs. 1 to 5, pp. 429 and 430.

(*The Railway Engineer.*)

The development of electric welding practice has suggested the possibility of an entirely new branch of structural engineering. Railway engineers, faced with difficult bridge reconstruction problems, are carefully considering the strengthening of old bridges by this method as an alternative to complete renewal.

Before embarking on any important bridge strengthening work of this kind, however, it is essential that some evidence should be available to show that welded work will fulfil the claims made by its sponsors; and for this reason the experiments and tests made by Mr. John Miller, B. E., LL. D., M. Inst. C. E., Engineer for the North-Eastern Area, London & North Eastern Railway, are of particular interest.

TABLE I.

Table showing stresses obtained at sample test points before and after strengthening.

TEST POINTS.	Stresses in tons per square inch under test load (with allowance for alteration in dead load due to added material).		Percentage increase in strength.
	Before streng-thening.	After streng-thening.	
Main girders.			
Point 36	2.45	1.19	105.5
— 44	1.74	0.91	91.2
Trough flooring.			
Point 10	1.27	0.74	71.5
— 11	1.78	0.96	85.5

The first experiments were made about a year ago on a 14-inch by 6-inch rolled steel joist. The joist was cut in half and one half left untouched while the other was sawn down the centre of the web (the neutral axis) for half its length, and in addition, the bottom flange was cut through at the centre.

The damaged half of the joist was then repaired by electric welding, and both halves, the untouched and the welded were tested to destruction under transverse loading. In these tests the welded half of the joist proved stronger than the untouched half.

In view of this satisfactory result, Mr. Miller decided to make a further and more elaborate test by welding plates to the girders and floor of a small span bridge, shown in figure 1, and testing the increase in strength obtained.

Before any strengthening work was undertaken, the bridge was carefully tested with a light test engine, and the stresses at several points, as indicated in figure 5, were noted by means of a Foster strainmeter so that the stresses could be compared with those as the same points after strengthening.

Figures 2, 3 and 4 show how the bridge was

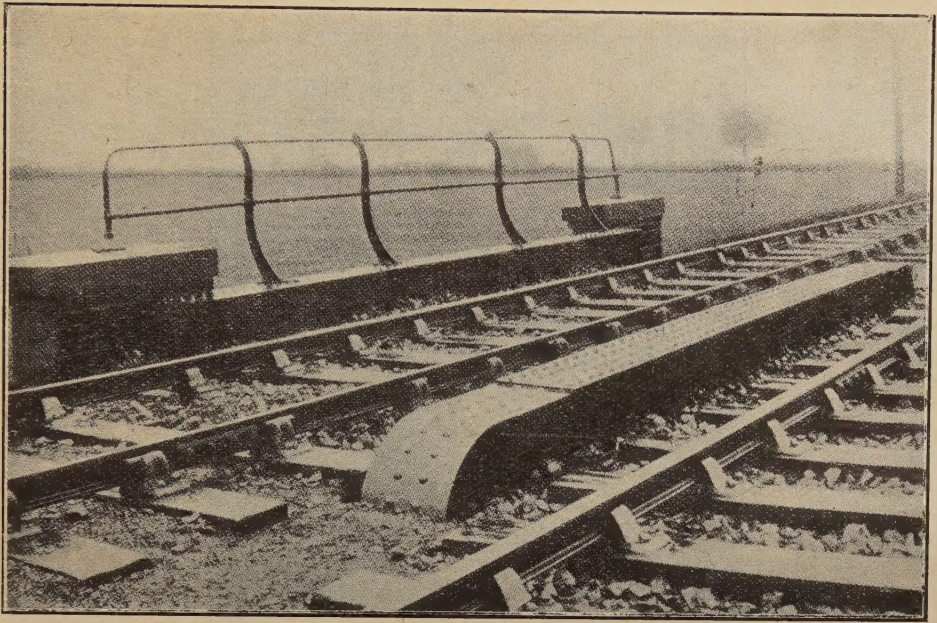

Fig. 1. — View of bridge before welding.

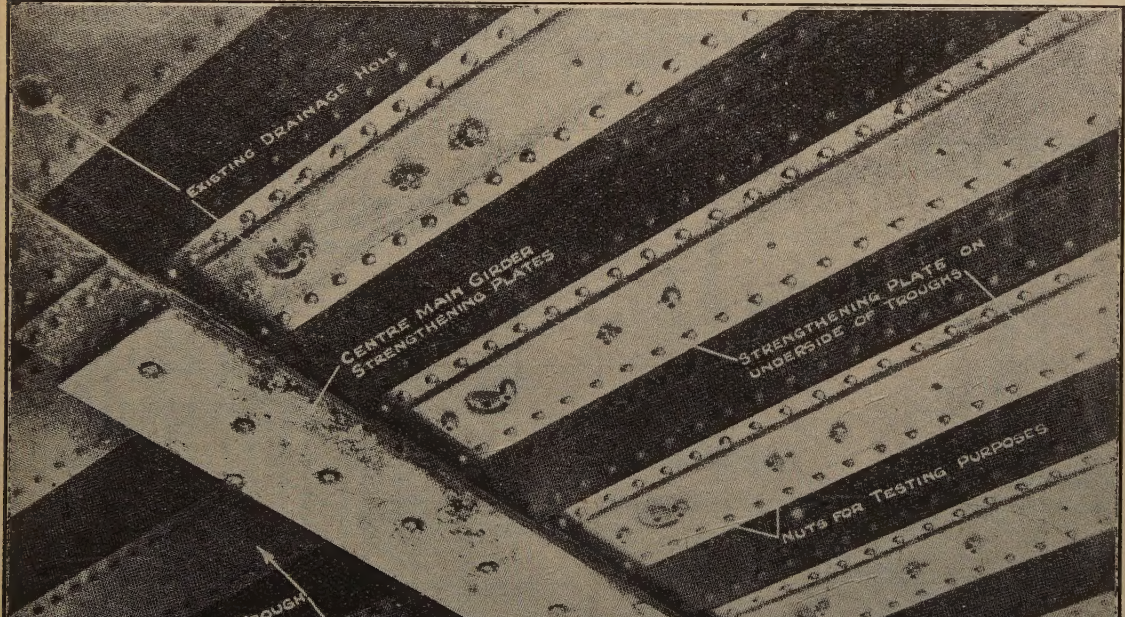
EXISTING DRAINAGE HOLE
CENTRE MAIN GIRDER STRENGTHENING PLATES
STRENGTHENING PLATE ON UNDERSIDE OF TROUGHS
NUTS FOR TESTING PURPOSES
UNSTRENGTHENED TROUGH
SPOT WELDS

Fig. 3. — View of underside of bridge showing additional plates on center girder and troughs.

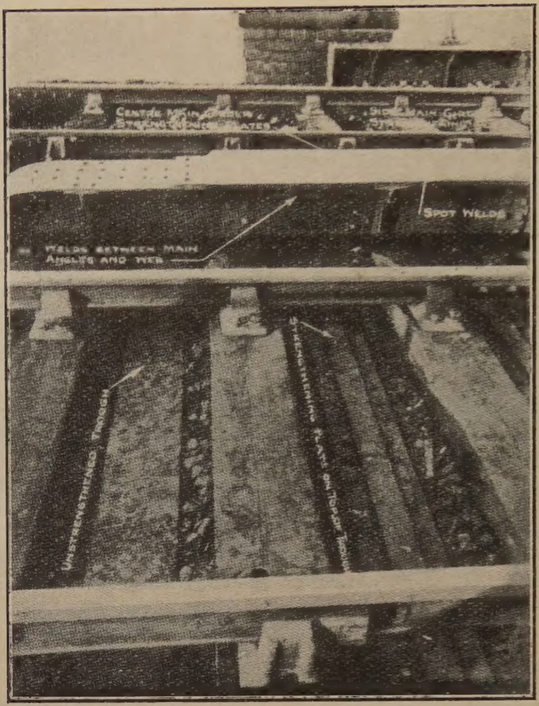
Centre Main Girder Strengthening Plates
Spot Welds
Welds between Main Angles and Web
Unstrengthened Trough
Strengthening Plate on Top of Trough

Fig. 2.— View showing strengthened and unstrengthened troughs, also additional plates on main girders.

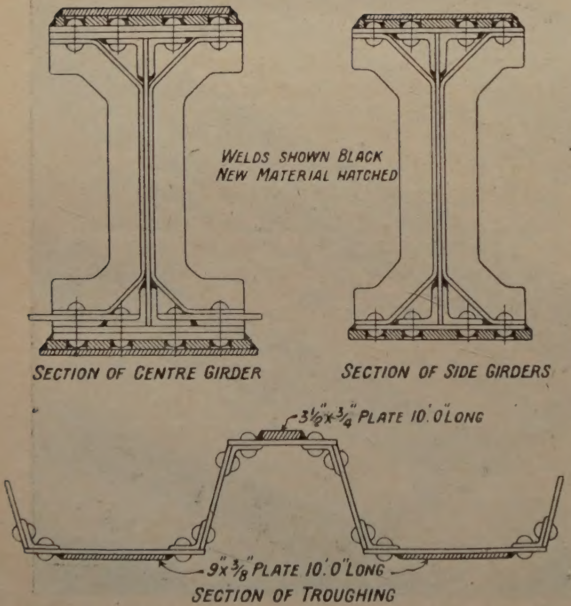

Fig. 4. — Details of welding of main angles to web and flanges.

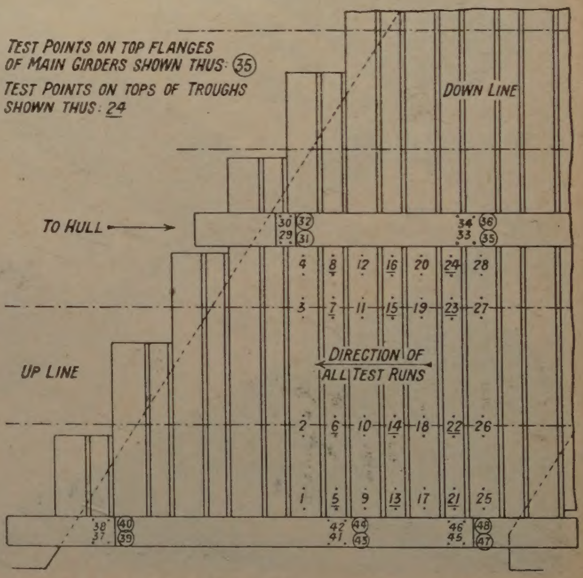

Fig. 5. — Point at which stresses were taken before and after strengthening.

strengthened. Plates were added to the flanges — the plate adjacent to the original flange plate being drilled to clear the rivet heads and then welded along the edges and through these holes. The second plate was then welded to the first along the edges, at the ends, and also at intervals along the centre line through holes specially drilled for the purpose. To give additional shear strength the main angles were welded to the web and to the flanges, indicated in figure 4. The trough flooring was strengthened by adding plates to the top and bottom flanges by edge welding.

After the bridge had been strengthened in this way, it was again tested with the same loads as before.

Table 1 shows the stresses obtained at sample test points before and after strengthening, with the percentage increase in strength expressed in terms of the allowable load. It will be seen that the increase in strength varies from 71 to 105 %:

An examination of the cost of this work shows that the cost of strengthening weak bridges by this method, up to the capacity for modern loading, is probably about 50 % of the cost of providing a new bridge of similar capacity.

These tests having demonstrated the possibility of economic bridge strengthening by means of electric welding, Mr. Miller is now proceeding with a definite programme of strengthening by this means, and three welding sets have been obtained for the purpose. The bridges on the Hull and Barnsley section of the London & North Eastern Railway (North-Eastern Area), which impose severe restrictions on the working of heavy engines, are the first to be taken in hand, but the work will later extend to other parts of the area.

The tests mentioned in this article were all carried out by the company's staff with a plant and electrodes supplied by the Quasi-Arc Company, of London. Mr. H. J. L. Bruff, Bridge Assistant to Mr. Miller, had general charge of the work, which was supervised on the site by Mr. F. L. Pawley from the office of the District Engineer, Mr. W. Mc. D. Malt, Hull.

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OBITUARY

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WILLIAM JOHN THORROWGOOD,

Late Signal and Telegraph Superintendent, Southern Railway.
Delegate of the Southern Railway and Reporter at the 10th Session (London 1925)
of the International Railway Congress Association.

We have learnt with deep regret of the death of Mr. William John Thorrowgood who for many years has been regarded as an authority on railway signal and telegraph matters.

Mr. Thorrowgood joined the service of the London & South Western Railway at Guildford in July 1877, and after having filled many posts was appointed Assistant Signal and Telegraph Engineer in 1918.

He remained in the service of the London & South Western Railway until 1923 when the « Southern Railway » was formed. He was then appointed Signal and Telegraph Superintendent of this latter company which position he held until his retirement on the 30 September 1927, after more than fifty years of railway service.

Mr. Thorrowgood was a member of the Institution of Electrical Engineers, of the Institute of Transport, of the Institute of Railway Signal Engineers (of which he was elected President for the year 1924, after having been a member of council for many years) and a member of the Signal Section of the American Railway Association. He was Chairman of the Railway Clearing House Signal Engineers' Conference, and of the Railway Clearing House Telegraph Engineers' Conference. He was also a Fellow of the « Permanent Way Institution » and an honorary member of the « Institution of Locomotive Engineers ». He was a member of the Ministry of Transport Committee on Light Signals.

Mr. Thorrowgood always took a keen interest in the work of the International Railway Congress Association.

He prepared for the London Session (1925) a noteworthy report on question IX « Fixed Signals » as regards the railways of the British Empire.

Two of his articles on « Signalling from the driver's point of view », and « Four-aspect coloured light signals » have been published in the monthly Bulletin of the Association.

We wish to express to his family our sincerest sympathy.

The Executive Committee.